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MYCOLOGY, SCIENTIFIC AND OTHERWISE [1]

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(WITH PORTRAIT)

Since mycology is a branch of science, its study should be pursued in a strictly scientific manner, that is, we should seek the truth without prejudice so far as it is humanly possible.

QUALIFICATIONS AND PREPARATION

Let us consider for a moment what qualifications and preparation are essential for success in mycological work. As is sometimes said of teachers, it may be said of mycologists, the greatest are born rather than made; that is, they inherit that innate love of nature and absorbing interest in all of her objects and works which helps to overcome all the difficulties and discouragements encountered in the pursuit of knowledge. Assuming the possession of the natural qualifications, we may consider the preparation necessary. Unfortunately our present home and school influences in many instances tend to discourage rather than to develop the natural interests and tendencies of children toward the study of nature. One of the most serious defects of our scientific training today, is too early specialization. The student should have a broad training in general science and courses in general botany, including the taxonomy of the flowering plants. It is pathetic to find professional pathologists and mycologists who do not know

[1] Address of the retiring President of the Mycological Society of America, Boston, Mass., December 28, 1933.

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the common wild plants which are the hosts of the fungi they study. I would not insist, however, that this be carried so far as to expect a mycologist to give the latest specific name to a specimen of *Crataegus* or *Rubus*.

Besides a broad view and concept of science in general, the student should have a good knowledge of languages, literature, and philosophy; as these subjects should all be useful as well as enjoyable in connection with the strictest scientific investigations and conclusions. A knowledge of the general history and development of science, and especially of botany and mycology, is of the greatest value in helping one to get a proper perspective and appreciation of the problems presented. The training must be broad and thorough in order to follow successfully what Tulasne calls "that most difficult of botanical paths, the way of mycology."

If one is preparing for taxonomic work, extensive and thorough field as well as herbarium studies must be made; and it is only after years of field, laboratory, and herbarium work with the best facilities and an abundance of material, as well as opportunity to study authentic and type material, that one can hope to successfully undertake monographic work and make a real contribution to our knowledge of the genera and species and their true relationships. It seems a mistake in most cases to encourage students to undertake monographic work for theses. One realizes this more and more as the years go by and we begin to get a real understanding of the difficulties involved.

My own experience may or may not have a bearing on this subject, depending on how it is interpreted. For nearly forty years I have been accumulating material and studying the species of *Xylaria* and *Hypoxylon*, as opportunity occurred, hoping some time to prepare a monograph of these genera. The more extensive our field studies, the greater the quantity of material examined, the more difficult it becomes to decide generic and specific limits. With little experience and scanty material, it may seem rather easy to distinguish these groups; but when you have an abundance of material from a very wide range of localities, many variations and intergrading forms are found which multiply the difficulties of segregation. Of course, this may all simply go to show that much study is not only a weariness of the flesh, but a cause of

mental confusion; or that your humble servant does not possess the divine afflatus necessary to recognize genera and species. Whatever the conclusion, the important thing is the demonstration and recording of the fact that these variations and intermediate forms do exist and must be reckoned with in our interpretation of plants and their relationships.

MOTIVES AND IDEALS

Motives and ideals are as important in scientific work as elsewhere, if one is to attain any real and permanent success. The primary motive in mycology should be the discovery of truth, advancement of our knowledge of the fungi, and the utilization of this knowledge for the physical, intellectual and social improvement of mankind. The old advice to "hitch your wagon to a star" still holds good, but, unfortunately, under the present depressing conditions the natural tendency is to hitch to anything that will bring bread and butter. Purely selfish motives, personal vanity, and desire for publicity, may appear to lead to temporary success, but do not usually secure for one a prominent or permanent place on the roll of honor of distinguished contributors to the advancement of science. It may be pointed out incidentally, that all our present social, economic, and political troubles are directly traceable to selfishness; a fact so obvious that few apparently recognize or admit it. Our ideal should be to attain as far as possible exact and complete knowledge of the organisms we study, in all their aspects and relations. The recognition of our vast ignorance should teach humility rather than pride and assurance. If one seriously contemplates the great marvels of organic life in any of their multitudinous and complex phases, it is difficult to understand how he can fail to be impressed with the magnitude of the problems which confront him and realize that, at best, we can only approximate the real truth. If we could really get an adequate conception of the difficulties to be encountered we might become totally discouraged and give up all effort.

Unfortunately, some of the work in systematic mycology at present can scarcely be called scientific. The multiplication of so-called "new species" based upon insufficient knowledge of those already described, insufficient material for study, and an

inadequate concept of species, has led to a multiplicity of synonyms and added to the confusion which already existed.

The practice of basing "new species" on difference of host, or even difference of part of host, especially of saprophytes or more or less omnivorous parasites, is certainly otherwise than scientific. If physiological differences between organisms can be demonstrated on different hosts or parts, they should be designated as physiological forms. The systematist should recognize that fungi, as most other plants, are in process of evolution and a state of unstable equilibrium; in other words, are constantly varying. The condition in one genus or species may, however, be much more unstable than that in a closely related group. What characters are most variable and to what degree and under what conditions, must be determined in each case by the most careful observation and field and laboratory study of an abundance of material from various localities.

To prevent further over-production of new species, it may be necessary to have an NRA code, strictly limiting the number anyone may produce per annum and also, perhaps, requiring a license to be issued only to those who pass a rigid examination showing that they have the necessary training, experience, and discrimination to recognize genuine species.

SOME PRESENT NEEDS

We may perhaps be permitted to point out here what we consider some of the greatest present needs for the advancement of systematic mycology. One of these needs is a thorough study and re-description of all the available type or authentic material of the species of fungi of the older authors; a very large number of which are at present imperfectly known or misinterpreted. Probably not one-fourth of the species found in Saccardo's "Sylloge Fungorum" are well enough described or known to be identified with certainty. Consequently, many names are differently applied by different mycologists, which causes much misunderstanding and confusion. Much valuable work in this direction has been recently done by von Höhnel and others, some of which, unfortunately, will have to be revised; as too much was undertaken to be thoroughly done in the time available. As these old species are more fully

known and recognized, a great number of our recent so-called new ones will fall into synonymy. It would advance systematic mycology more to re-describe, illustrate, and make well known, one of the uncertain older species than to describe a so-called "new species" based, too often, on insufficient material and study, and which may already have several names.

In speaking of descriptions, we have gone from one extreme to the other; from the one or two line descriptions of some of the older mycologists to the one or two page descriptions of the more recent. A description need not be long in order to give a clear and definite idea of a species. What is needed is a concise and accurate description of the essential features of the organism, emphasizing the particular characters which separate it from its nearest relatives. In order to compare the different characters readily the different parts of the fungus should always be described in the same order. In some instances, one finds emphasized as a specific character of a new species one not mentioned in the description of its nearest relatives. Is one to infer that this character is lacking in the other species or that it is different? There is little satisfaction or consolation to find at the end, in connection with the description of a new species in which no particular specific distinction is pointed out, the note: "This is a well marked species easily distinguished from its relatives."

In addition to adequate descriptions good illustrations should be given wherever possible. The best descriptions and illustrations, however, do not always make possible certain identification of a species. Cotype or authentic specimens should be made available. As already stated, the material upon which a species is based should be ample and portions of it should be deposited in the large herbaria for comparison by monographers. The usual excuse for not doing this is the scantiness of the type material. If the material is too poor or scanty for division, this would, in most cases, be sufficient reason for withholding the publication; as it would only add one more to the great mass of uncertain species already existing. Since, in the present state of our knowledge, genera and species of fungi are largely mental concepts; it is best from a practical as well as a scientific standpoint to be conservative in our concepts and interpretations and to follow a median course, rather than that of

the so-called "lumpers" or "splitters." In this connection the need for more careful and much more thorough field studies and collections should be emphasized. One who has not examined the collections in our larger herbaria, either in this country or in Europe, would scarcely believe how few and poor are the specimens of many of even the common species. In most cases it seems to be taken for granted that if the species is a common one two or three specimens in a herbarium are sufficient. This is a great mistake. Many of our common species are very variable and in some cases, perhaps, two or more are confused under a single name, so that abundant and numerous gatherings are necessary for an adequate study of the group. A large quantity of much better material from a wider range of localities must also be accumulated before satisfactory monographic work can be done. In this connection I would call attention to the desirability of aiding, encouraging, and developing a much larger number of amateur collectors and students of fungi. At present the race seems to be nearly extinct in this country. Amateurs may be of the greatest assistance in aiding and advancing systematic studies of fungi by supplying taxonomists and herbaria with good specimens and field notes on the species growing in their localities, and at the same time they may derive a great deal of pleasure and recreation from the work.

In this connection I may repeat what I have said before; that one of the greatest discouragements to amateur botanists is the frequent change of generic and specific names. Fortunately, thus far, no very widespread and serious attempts have been made to change our fungus names on a strict priority basis, and we know of nothing that would interfere more with the advancement and popularization of systematic mycology than a general attempt to apply this plan to the names of fungi; as it would result in a change of a great many of our best known names of genera and species. The names at present in general use should be conserved, if we are ever to have a reasonably uniform and stable nomenclature. In this connection we may also call attention to the present tendency to use outlandish and sesquipedalian names. Names are for convenience and practical purposes and should therefore be as short and suggestive as possible. Some of the

generic and specific names which are being perpetrated at present are indefensible and intolerable, and though they may have some temporary recognition they will, I believe, eventually be discarded. Consider the following mild examples: *Chaetobasidiella vermiculariodes, Ectotrichophyton mentagrophytes* and *Methysterostomella argentinesis.* Another need for the advancement of systematic mycology is that of centralized publication of taxonomic work and especially of descriptions of new genera and species. If such material could be published in a single journal in each country, it would be a great step in the direction of economy and efficiency, and a great saving of time and labor for all concerned.

Another need is more life history studies. Recent work has shown that such studies may throw much light upon the origin and relationships of different groups. Such work also reveals the fact that this line of investigation does not give promise of providing an easy solution to our taxonomic problems; as species showing close relationship according to their perfect stages are sometimes found to have quite diverse conidial forms and vice versa.

The study of heterothallism and hybridization has also opened up a vast field for investigation and shows the possibilities of complications as to the origin and systematic relations of many groups, especially the Ascomycetes.

In connection with life history studies, in many cases efforts to obtain all the spore stages of an organism in pure culture have failed. In some of these instances, we know that failure has been due to heterothallism. In many other cases, however, failure is probably due entirely to lack of providing natural conditions in the way of nutrition and environment for the fungus. If we could successfully reproduce natural conditions in the laboratory or in the open, under control, there is every reason to believe that success would be attained.

REWARDS

No one needs reminding that Mycology is not a road to wealth, and that large stipendiary emoluments are hardly to be expected. However, a real mycologist, as any other laborer, is worthy of his hire. Just at present, the demand for professional mycologists is not great, but those who are impelled by a deep desire for knowledge of this subject and who have great patience and perseverance,

will find some way of securing a livelihood and the comfort to be derived from knowing that one is contributing to the advancement of knowledge and to a broader appreciation and understanding of the wonders of Nature.

We have already emphasized the fact that mycological work demands persistence, patience, and accurate observation; careful experiments, and painstaking records and measurements. The study of mycology, however, has other phases than these more or less impersonal ones which are pursued with scientific detachment and freedom from imagination, sentiment or emotion. The mycologist may and should enjoy the beauties and marvels of nature and speculate about her mysteries without interfering with the accuracy of his observations or the strict and logical interpretation of his results. In other words, there is no reason why the "fun" should be taken out of fungi. The joy of discovery and the intellectual pleasure to be derived from the contemplation and appreciation of the wonderful variety of forms, their complexity of structures and the mysteries involved in their origin and evolution, their life histories and relationships, and from the discovery of unknown facts and forms—these are some of the richest rewards for the student.

Mycologists, as others, sometimes have their pessimistic moods. Tulasne tells us that Fries on such an occasion said: "Mycology is one of those despised and neglected studies which bring their pursuers neither money nor glory." As most of us know from experience, however, it may bring something much more satisfying and valuable than either money or glory. To quote the poet: "To him who in the love of nature holds communion with her visible forms she speaks a various language." For inspiration and encouragement one should read the lives of such men as Darwin, Huxley, Wallace and others. Much good advice may be obtained from reading the introduction to Tulasne's classic work recently translated. He says: "If the mycologist of today desires as is fitting nothing more than to please and at the same time provide the reward, let him throw away every fiction contrary to nature and understand that he has reached the height of virtue and glory, when by hard labor and wise study he has attained the truth and has revealed it in full daylight."

Probably in no branch of biology is there a broader field and greater opportunity for discovery and contribution to knowledge than in Mycology. It not only furnishes an extensive field for scientific discovery, recreation, and pleasure, but great opportunity for practical application in agriculture, the arts and industry. All the time at my disposal might have been spent in listing the most important economic applications and aspects of the subject.

Let us therefore continue the good work with higher ideals and greater zeal, relying upon the assurance that Mother Nature will do for us what she did for Agassiz:

> "Whenever the way seemed long,
> Or his heart began to fail,
> She would sing a more wonderful song,
> Or tell a more marvellous tale."

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

A NEW SPECIES OF LEPIOTA[1]

S. M. Zeller

(with plate 26)

This mushroom is one of the very first to make its appearance after the early fall rains. It is one of the most common Agarics of the fall season to be found throughout the Willamette Valley. *Lepiota Barssii* grows in locations similar to those where the smooth *Lepiota* (*L. naucina*) is found, the two sometimes near each other under the same ecologic and climatic conditions. *L. Barssii* generally comes out a few days earlier than *L. naucina* but the latter may be found for a considerable time after *L. Barssii* has disappeared.

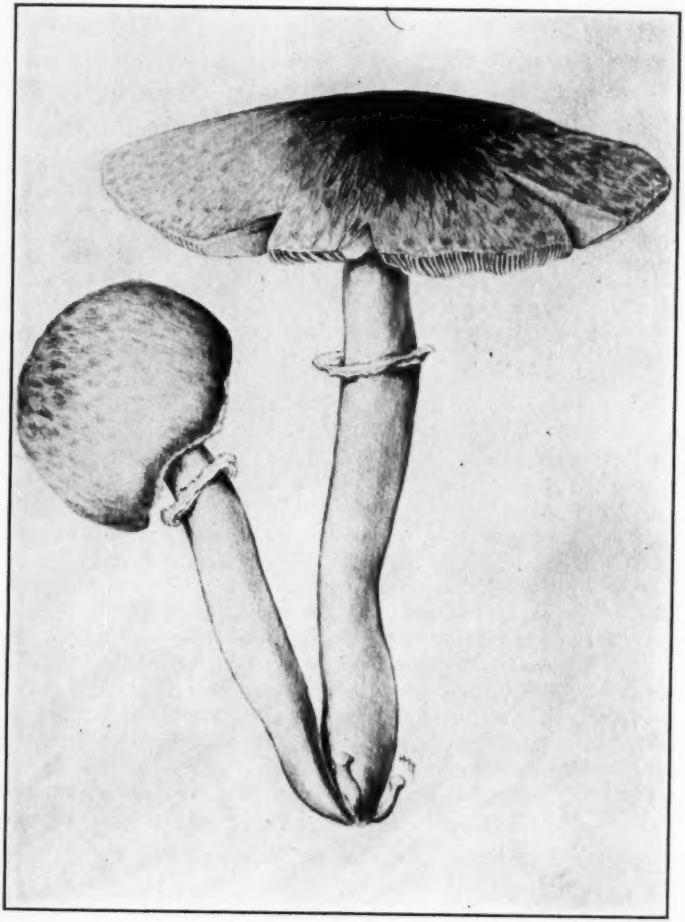
L. Barssii occurs in pastures, plowed fields and gardens, or in stubble (grain) fields. Its fructifications thrive and grow to their largest size around old straw stacks or manure piles. A favorable habitat is strawberry or potato plantings.

In favorable locations this mushroom may be collected in large quantities and it has proven to be very palatable. For many years it has been collected by mycophagists without discrimination from *L. naucina,* with which it compares very favorably as an edible mushroom.

This mushroom is a beautiful *Lepiota* belonging to the group *Procerae-annulosae*, as described by Kauffman.[2] It is large and of stately form, as illustrated in plate 26, a photograph of a water-color painting by Dr. Helen M. Gilkey. *L. Barssii* is perhaps more closely related to *L. naucina* than to other species of the genus, but is easily distinguished by the characteristically gray color and scaly surface of the pileus. In *L. naucina* the gills are more nearly equal, then slightly narrowed behind, sometimes almost sinuately indented, and of much softer texture than those of the same age in *L. Barssii*. The stem of the latter is not enlarged at the base as in *L. naucina*.

[1] Published as technical paper No. 210 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany and Plant Pathology.

[2] Kauffman, C. H. The genus *Lepiota* in the United States. Mich. Acad. Sci. Papers **4**: 311–344. *illus.* 1924.



LEPIOTA BARSSII

The writer takes pleasure in dedicating this species to his botanical colleague, H. P. Barss, Head Professor of Botany and Plant Pathology, Oregon State Agricultural College. Professor Barss was one of the first to notice the characters by which this species is distinguished from *L. naucina*. The diagnostic description follows:

Lepiota Barssii sp. nov.

Gregaria vel caespitosa: pileo carnoso, 7–15 cm. lato primito subgloboso vel ovoideo dein convexo vel plano-expanso obtuso-umbonato vel subumbilicato; margine interdum radiatim rimoso; superficie arida fumoso-grisea vel "drab," [3] disco fuscidiore, fusco vel "Cinnamon drab," [3] squamulis fibrillosis fuscis vestito; contextu primito albo dein sordido postice crasso margine pertenui, odore et sapore grato; lamellis 7–16 mm. latis inaequalis postice tenuitiore subconfertis liberis albis mutans straminescens, acie levis sterilis; stipite 8–18 mm. crasso 8–12 cm. longo subaequali, farcto dein cavo, glabro vel sericeo albo; annulo amplo supero collarioideo saepe mobili persistenti albo, extus laminis stipitis et veli efformato; sporis ellipsoideis-ovoideis levibus albis guttulatis, magnitudinis variabilis 7.5–9.5 × 5–6 μ.

Ad terram in pratis et in horto, Oregon occid., Amer. Bor.

Gregarious or caespitose; *pileus* 7–15 cm. broad, fleshy, at first subglobose to ovoid, then convex to plano-expanded, obtusely umbonate to subumbilicate, sometimes splitting radially at margin, *surface* dry, smoke-gray to drab with darker, fuscous or cinnamon darb umbo, covered by fibrillose, fuscous scales; *flesh* at first white, then sordid, thick at disk but very thin toward margin; *gills* 7–16 mm. broad, unequal, narrower behind, close but not crowded, free, edge even, sterile, white changing slightly straminеous; *stem* stout, 8–18 mm. broad above, 10–15 mm. broad below, 8–12 cm. long, almost equal, stuffed then hollow, glabrous or silky above and below the ring, white within and without; *annulus* formed from veil and outer layer of stem, white, collar-like, persistent, superior, often movable at maturity; *spores* ellipsoid-ovoid, variable in size in same plant, 7.5–9.5 × 5–6 (ave. 7.7–5.2) μ, smooth, white, guttulate; *odor* and *taste* pleasant.

In pastures, plowed fields, or gardens, September. Very common throughout the Willamette Valley, western Oregon.

OREGON STATE AGRICULTURE COLLEGE,
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EXPLANATION OF PLATE 26

Lepiota Barssii. Photograph of a water-color painting by Dr. Helen M. Gilkey.

[3] Ridgway, Color Standard.

THE HYDNACEAE OF IOWA. III. THE GENERA RADULUM, MUCRONELLA, CALDESIELLA AND GLOIODON

L. W. MILLER

(WITH PLATE 27)

RADULUM Fries, Elench. Fung. **1**: 148. 1828.

Resupinate or rarely reflexed, ceraceous; teeth blunt, generally coarse, deformed, irregularly scattered or confluent. Growing on wood.

KEY TO THE SPECIES OF RADULUM

1. Narrowly reflexed, sometimes resupinate, thick, not cracking; clamp connections numerous; spores 5–7 × 3–4 μ.....3. *R. pallidum.*
1. Resupinate, adnate, varying in thickness, sometimes cracking; clamp connections present or absent; spores usually larger.....(2)
   2. Cracking; clamp connections few or absent; spores 6–8 × 3–4 μ
      2. *R. quercinum.*
   2. Generally not cracking; clamp connections numerous; spores 8–12 × 3–4 μ, curved.....1. *R. orbiculare.*

1. RADULUM ORBICULARE Fries, Elench. Fung. **1**: 149. 1828. (PLATE 27, FIG. 1.)

Hydnum Radula Fries, Syst. Myc. **1**: 422. 1821.
Sistotrema Radula Pers. Myc. Eu. **2**: 195. 1825.

Resupinate, orbicular, becoming confluent, soft ceraceous, light ochraceous-buff; margin similar or byssoid and white; teeth variable, cone-shaped to cylindrical or plate-like, obtuse, scattered or fascicled; hyphae 2–4 μ in diameter, distinct, with numerous clamp connections, not arranged in distinct zones; basidia 20–30 × 5–6 μ, clavate, with 4 sterigmata; spores 8–12 × 3–4 μ, cylindrical, curved, smooth, hyaline.

The large, curved, cylindrical spores clearly separate *Radulum orbiculare* Fries from the other Iowa species of *Radulum*. This species seems close to *Radulum hydnans* Schw. and *Corticium colliculosum* Berk. & Curt. Burt regards these latter two as synonyms and belonging in the genus *Corticium*, and therefore

distinct from *Radulum orbiculare*. He states that *Corticium hydnans* (Schw.) may be distinguished in doubtful cases from *Radulum orbiculare* Fries by the absence of gloeocystidia. I have examined many specimens of *Radulum orbiculare* from Europe and several so determined by Burt and was unable to find definite gloeocystidia in any of these. The spore size as recorded by Burt is considerably smaller for *Corticium hydnans*.

Fairly common in Iowa. Collected on deciduous wood from April to September. Reported from Washington and from many regions in the central and the eastern United States, including Iowa.

2. RADULUM QUERCINUM Fries, Hymen. Eu. 623. 1874. (PLATE 27, FIG. 3.)

Hydnum quercinum Fries, Syst. Myc. **1**: 423. 1821.
Hydnum fagineum Pers. ex Fries, Syst. Myc. **1**: 433. 1821.
Sistotrema fagineum Pers. Myc. Eu. **2**: 194. 1825.
Radulum fagineum Fries, Elench. Fung. **1**: 152. 1828.

Fructification resupinate, orbicular then confluent and effused, sometimes subdecorticating, crustaceous-ceraceous, adherent, often cracking in drying, cinnamon-buff to clay color; margin thin, similar or slightly villose, usually lighter in color; teeth variable, short and obtuse to long, cylindrical and slightly pointed; hyphae 2–5 μ in diameter, mostly thin-walled, with few clamp connections; basidia clavate, with 2–4 sterigmata; spores 6–8 $\times$ 3–4 μ, ellipsoid to short cylindrical, depressed laterally, smooth, hyaline.

The European descriptions of *Radulum quercinum* Fries indicate a fungus very near to *Radulum pallidum* Berk. & Curt. Six specimens of the former species from Litschauer, Bourdot and Bresadola were examined at the New York Botanical Garden and the Farlow herbarium. These seemed to be distinct. The hyphae lack the characteristic clamp connections and the spores are slightly longer. The thin, adnate, resupinate fructification is usually cracked to the substratum. There is little suggestion that this type of fructification may occur reflexed as in *Radulum pallidum*.

Rare in Iowa. Collected in October on deciduous wood. Schweinitz reports the occurrence of *Hydnum quercinum* Fries from Pennsylvania.

3. RADULUM PALLIDUM Berk. & Curt. Grevillea **1**: 145. 1873. (PLATE 27, FIG. 2.)

Resupinate to narrowly reflexed, tomentose and white on the upper surface; orbicular at first, then confluent and slightly effused, adnate, ceraceous, thick, usually not cracking, pinkish buff to vinaceous-buff and vinaceous-fawn; margin tomentose, white; teeth variable, short, obtuse, smooth or slightly fimbriate, often confluent in irregular groups; hyphae 2–4.5 μ, distinct, with numerous clamp connections, more or less parallel along the substratum and ascending obliquely to the compact hymenium, hyaline or granular; basidia 15–35 $\times$ 4–7 μ, clavate, with 4 sterigmata; spores 5–7 $\times$ 3–4 μ, ellipsoid, obliquely attenuated, slightly depressed laterally, smooth, hyaline.

This species resembles *R. quercinum* Fries as that species is known in Europe. It seems to differ in its often reflexed margin, the abundance of clamp connections and slightly smaller spores. Resupinate specimens usually can be distinguished by the vinaceous tinge of the hymenium, the thicker and less cracked fructification and the more abrupt, tomentose margin. These macroscopic characters are exceedingly variable, however, as is true of other species of *Radulum*. This species seems also to be known as *Radulum orbiculare* Fries in this country, judging by the many herbarium specimens so referred. Lloyd clearly and accurately separated the two in his paper, *The genus Radulum*, 1917. Later (Myc. Writ. 1079. 1921) he considered *R. pallidum* merely the American representative of *R. orbiculare*. The longer, curved spores, the invariably resupinate fructification and the softer, ceraceous texture seems clearly to separate *R. orbiculare*. Iowa specimens are identical with a specimen at The New York Botanical Garden which Banker has compared with the type. They also agree with Lloyd's material.

Abundant on decaying wood and bark of oak and other frondose species, often on charred wood; collected throughout the year. Its occurrence is widely reported from the central and eastern states.

MUCRONELLA Fries, Hym. Eu. 629. 1874.

Subiculum absent or consisting of a floccose, fugacious mycelium; spines subulate, entire. Growing on wood and bark.

KEY TO THE SPECIES OF MUCRONELLA

1. Spines gregarious but not fascicled; spores 4–7 × 2–4 μ..1. *M. aggregata.*
1. Spines in fascicles of 2–8; spores 14–16 × 10–12 μ.....2. *M. Ulmi*

1. MUCRONELLA AGGREGATA Fries, Monog. Hymen. Suec. **2**: 280. 1863. (PLATE 27, FIG. 7.)

Subiculum absent or consisting of a few spreading hyphae; spines 0.5–1.5 mm. in length, subulate, entire, acute, gregarious, in groups, reported white when fresh, chamois in the herbarium; cystidia absent; hyphae 2–4 μ in diameter, sometimes 6–8 μ in the interior of the spine, thin-walled, with few clamp connections, accompanied by calcium oxalate crystals; basidia 10–16 × 3–5 μ, clavate; spores 4–6.5 × 2.5–3.5 μ, ellipsoid, smooth, hyaline.

This species is recognized by the gregarious spines which are more or less distinctly separated from each other. It seems closely related to *Mucronella calva* (Alb. & Schw.) Fries, *M. minutissima* Peck., *M. abnormis* P. Henn., and *M. ramosa* Lloyd. There seems to be little difference in the microscopic structure of these species as described in the literature. A speciment labeled *M. calva* (Alb. & Schw.) from the herbarium of Bresadola at The New York Botanical Garden is identical with *M. aggregata* as here understood. Lloyd (1922) states that *M. ramosa* "is similar to *M. aggregata* except the separate plants appear as if branched." An old specimen (No. *265*) in the University of Iowa herbarium answers very well to Lloyd's description and figure (*Fig. 2036*) of *M. ramosa* but is not sufficiently distinct from *M. aggregata* to justify specific rank.

Three specimens of *M. aggregata* have been collected in Iowa. On decaying wood in November. Its occurrence in Maine, New York, Ohio and Iowa has been reported.

2. MUCRONELLA ULMI Peck, Ann. Rep. N. Y. State Mus. **54**: 154. 1901. (PLATE 27, FIG. 4, 5.)

Subiculum absent; spines 1–3 mm. in length, 0.2–0.35 mm. in diameter, in fascicles of 2–8, rarely single, terete, subulate, acute, soft, curved, dusty dull violet with a white base, soon becoming white and mealy; hyphae 2.5–3 μ in diameter, not incrusted, walls thickened, with few septa and clamp connections, hyaline; basidia large, 30–35 × 10–15 μ, clavate, with 4 sterigmata, accompanied by slender, hyaline and slightly projecting, paraphysoid hyphae;

spores 14–16 × 10–12 μ, obovate, smooth, with a prominent apiculus, hyaline.

This species is recognized by its fascicled spines, its violet color and the large spores.

In the original description of *M. Ulmi* the spines are recorded as greyish or pallid. Peck does not refer to the spore characters. Overholts (1920) made some additional notes on the same species. He described the fructification as white, drying gray but was unable to obtain spores. Mention was made of specimens with a lavender or purplish tint. A fungus has been collected repeatedly in Iowa to which the descriptions of Peck and Overholts closely apply. The spines when fresh are usually distinctly violet in color and large, lemon-shaped spores are produced. Several specimens were collected which had whitish spines but these were assumed to have faded. Recently the type of *M. Ulmi* in the New York State Museum at Albany was examined and found to be unquestionably the same species. The type specimen has whitish spines and the large characteristic spores.

This fungus is very inconspicuous but apparently common in Iowa. Collections were made from June to November on the bark of both living and dead trunks of willow, oak, ash and elm. The occurrence of *M. Ulmi* seems to be recorded only from the type locality in New York and from Pennsylvania by Overholts.

CALDESIELLA Sacc. Michelia **1**: 7. 1877.

Resupinate, soft, floccose, dark; spores subspherical, colored. Growing on wood.

CALDESIELLA FERRUGINOSA (Fries) Sacc. Michelia **2**: 303. 1881. (PLATE 27, FIG. 6.)

Hydnum ferruginosum Fries, Syst. Myc. **1**: 416. 1821.
Hydnum ferrugineum Pers. Myc. Eu. **2**: 189, *non* Fries. 1825.
Hydnum crinale Fries, Epicr. 516. 1838.
Acia ferruginea (Pers.) Karst. Bidr. Finl. Nat. Folk **37**: 112. 1882.
Odontia barba-jovis Pat. Tab. Fung. **3**: 110. 1884.
Hydnum tabacinum Cooke, Grevillea **14**: 129. 1886.
Phaeodon tomentosus Schrad. ex Schröt. Krypt.—Fl. Schles. **3**[1]: 458. 1889.

Acia tomentosa Schrad. ex Karst. Bidr. Finl. Nat. Folk **48**: 362. 1889.

Odontia crinalis (Fries) Bres. Atti Accad. Rovereto **3**: 96. 1897.

Odontia ferruginea Pers. ex Banker, Bull. Torrey Club **29**: 439. 1902.

Caldesiella crinalis (Fries) Bourd. & Galz. fide Rea, Brit. Basid. 651. 1921.

Resupinate, effused, floccose, slightly separable, ochraceous-tawny to mummy brown; margin similar or slightly lighter in color; spines subulate, conical, acute, terete, 2 mm. or less in length; hyphae 2–5 μ in diameter, loosely interwoven and in slender branching strands in the subiculum, with numerous clamp connections, mostly dark colored; basidia 40–60 $\times$ 6–8 μ, cylindrical, with 2–4 prominent sterigmata measuring 5–8 μ in length, becoming colored; spores 8–10 $\times$ 7–9 μ, subspherical, tuberculate, benzo brown in mass.

This species is well marked. The dark-colored, tomentose, resupinate fructification and the large, dark, tuberculate spores are distinctive characters.

A number of specimens were collected in Iowa from the same log from August to November in 1931 and 1932. This log was lying in an open pasture which had recently been cleared. When first collected the fungus covered a considerable area of the underside of the log and crept over about 8 square inches of the ground immediately under the log. The portion on the ground bore distinctly upright spines as well as spines appressed somewhat to the subiculum. A small specimen was also collected at Milford, Iowa in 1932. Apparently uncommon in Iowa. It is known from California and at least eight central and eastern states. A fragment of the type of *Hydnum tabacinum* Cooke, a specimen of *Hydnum crinale* Fries from the herbarium of Fries, and a specimen of *Odontia crinalis* (Fries) from Bresadola at The New York Botanical Garden seem to be identical with specimens collected in America.

GLOIODON Karst. *emend.* Banker, Mycologia **2**: 10. 1910.

Resupinate or pileate and laterally sessile, tough, dark, consisting of branched processes in a coarse tomentum; spores faintly roughened, short elliptical, hyaline. Growing on wood.

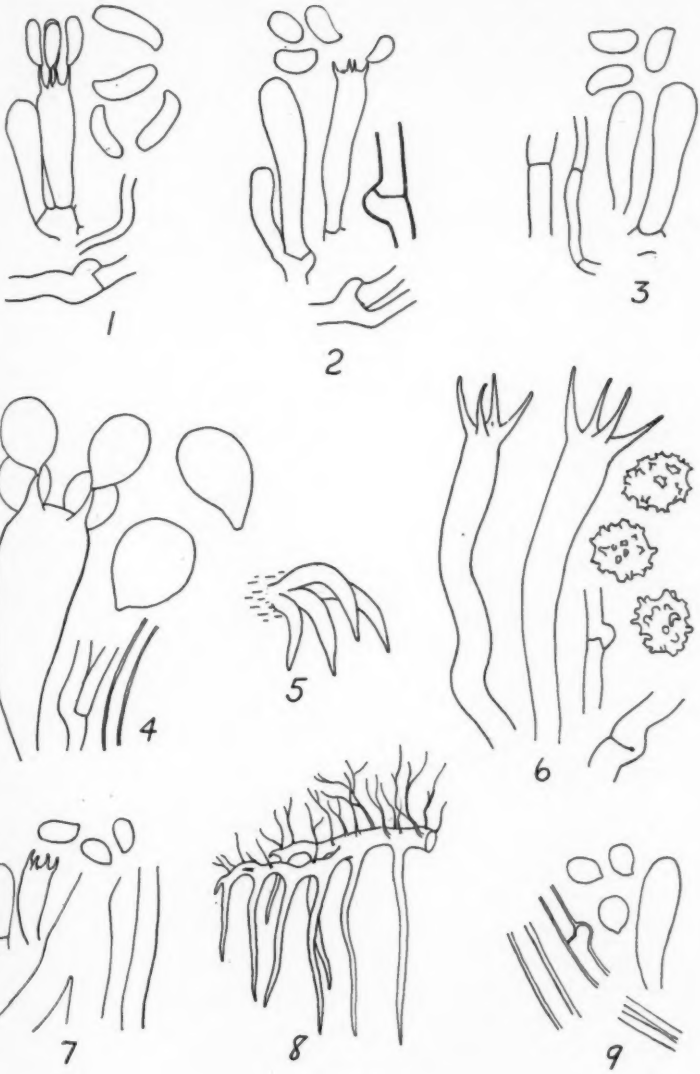
GLOIODON STRIGOSUS (Fries) Karst. Medd. Soc. Faun. Fl. Fenn. **5**: 28. 1879. (PLATE 27, FIG. 8, 9.)

Hydnum strigosum Swartz ex Fries, Syst. Myc. **1**: 414. 1821.
Hydnum stratosum Berk. Lond. Jour. Bot. **4**: 307. 1845.
Sclerodon strigosus (Fries) Karst. Bidr. Finl. Nat. Folk **48**: 361. 1889.
Mycoleptodon strigosum (Fries) Pat. Tax. Hymén. 117. 1900.
Leaia piperata Banker, Mem. Torrey Club. **12**: 175. 1906.
Leaia stratosa (Berk.) Banker, Mem. Torrey Club. **12**: 177. 1906.
Gloiodon stratosus (Berk.) Banker, Mycologia **2**: 11. 1910.

Fructification resupinate to reflexed or dimidiate, occasionally stratose from successive growths, 5 mm. or less in thickness, dry, tough, fibrous, cinnamon-brown, consisting of flexible, repeatedly branched processes which are partially submerged in a dense, coarse tomentum; margin fimbriate from the projecting ends of the branches or tomentose; spines 3 mm. or less in length, 0.2 mm. or less in diameter, slender, terete, acute, arising from the branched processes which they resemble in texture, mummy brown with a thin, light mineral gray surface layer when dry; hyphae 2.5–5 μ in diameter, septa widely separated, with clamp connections in the mycelial strands, faintly colored; basidia clavate; spores 4.5–5.5 $\times$ 3.5–4 μ, subspherical to elliptical, faintly roughened, hyaline.

This species may be recognized by the layer of ramifying processes which support the spines below and the dense tomentum above. It is reported as having an intensely acrid taste.

In 1897 Bresadola indicated that *Hydnum strigosum* Fries, applied to a pileate form, was identical with *Hydnum stratosum* Berk. which was based on a stratose, resupinate specimen. Banker (1906) apparently was not familiar with Bresadola's paper and had not seen authentic or type material. He applied *Steccherinum strigosum* to an entirely different fungus. He recognized *Hydnum* (*Leaia*) *stratosum* Berk. and applied the new name *Leaia piperata* to pileate forms of the same species. Later (1910, 1913) Banker became familiar with the true *Hydnum strigosum* and reported having been the types of the species concerned. Consequently, the specific name *strigosum* was employed rather than *piperata* for the pileate forms. He again regarded the resupinate speci-



HYDNACEAE

mens and the pileate specimens as two distinct species. I have examined Banker's material and the type of *Hydnum stratosum* Berk. at The New York Botanical Garden and am convinced that Bresadola's conclusions are correct.

Collected once in Iowa by Holway. The specimen is in The New York Botanical Garden. Its occurrence in Iowa is also reported by Cejp but the specimen in the University of Iowa herbarium so determined by him is *Irpex pachyodon*. Reported from seven eastern states. Apparently rare.

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EXPLANATION OF PLATE 27

All figures, except 5 and 8, drawn with camera lucida at a magnification of 1650 diameters, reduced to × 1000 in reproduction. Hyphae, basidia and spores are shown in each figure except 5 and 8.

Fig. 1, *Radulum orbiculare;* 2, *R. pallidum;* 3, *R. quercinum;* 4, *Mucronella Ulmi;* 5, *M. Ulmi,* habit sketch; 6, *Caldesiella ferruginosa;* 7, *Mucronella aggregata;* 8, *Gloiodon strigosus,* a portion of a branching process showing the position of the teeth below and the brownish tomentum above; 9, *G. strigosus.*

THE DEVELOPMENT OF CORDYCEPS AGARICIFORMIA [1]

WILBERT A. JENKINS

(WITH PLATES 28 AND 29 AND 1 TEXT FIGURE)

INTRODUCTION

The members of the genus *Cordyceps* constitute a unique group of approximately two hundred species. With the exception of two species (*Cordyceps agariciformia* (Bolt.) Seaver and *C. parasitica* (Willd.) Seaver) which attack the hypogeous fruits of the fungus *Elaphomyces,* all these species occur as parasites on insects or spiders.

Our knowledge of the biology of *Cordyceps* is essentially limited to early studies of entomogenous species (de Bary, **4**, **5**; Tulasne, **40**; Sopp, **39**; Atkinson, **1**; Pettit, **36**). These investigators confined their studies to a single stage in the cycle, principally the development of the perithecium and ascospores (Fisch, **15**; Lewton-Brain, **29**; Maire, **30**) because they lacked sufficient material to study the entire cycle of development or because they were handicapped by the lack of suitable microtechnical methods. Recently, Varitchak (**41**, cf. also Varitchak, **42**) contributed to our knowledge of the morphological and cytological development of one of the entomogenous species. Facts established from studies on supposedly closely allied genera (Vincens, **45**; Killian, **25**; Gäumann, **17**) have been employed as a means of arriving at an understanding of the genus *Cordyceps.*

In the present investigation an attempt is made to follow the course of development, both morphological and cytological, of *C. agariciformia* from the period extending from the sclerotial stage to the maturation of the ascospores. There has been to date only one such investigation (Varitchak, **41**) and since this work was

[1] A revision of a dissertation submitted to the Board of University Studies of the Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy, June, 1933.

done on an altogether different species, the present contribution should afford opportunity for comparison and contrast.

MATERIALS AND METHODS

The material of *Cordyceps agariciformia* consisted of clavae ranging in stages of development from those which had emerged to a height of only a few millimeters above the parasitized *Elaphomyces* fruits up to and including clavae which bore mature perithecia and spores. The first collection of material was made at Gainesville, Florida, fixed in Gilsons fluid on February 24, 1924 and sent to the writer in November, 1932. The second collection included a rather complete series of developmental stages and was received in living condition from Cocoa, Florida on January 17, 1933. The third collection consisted of more mature stages and was sent from Gainesville on February 4, 1933. This living material, on arrival, was still attached to its host and was apparently healthy. The material was immediately washed in running water and fixed in formalin-acetic-alcohol, care being taken to cut the larger clavae into appropriate sizes to permit rapid penetration of the fixative. Due to the presence of adhering and incorporated sand particles on the *Elaphomyces* fruits and in the very young clavae, it was found necessary to desilicify these, after fixation, with hydrofluoric acid. The material was then dehydrated and embedded in paraffin. Sections were cut five, eight and ten microns in thickness in transverse, radial and tangential planes.

Various stains and combinations of stains were used, as Gram's Gentian violet (Couch, **10**), Heidenhain's iron alum haematoxylin in combination with fast green, the same in combination with orange III in clove oil, safranin alone and Heidenhain's iron alum haematoxylin alone. While Gram's stain proved very useful in differentiating the structure of the opercula of the asci, walls of the asci and vegetative mycelium, and especially as a differential stain to show the relation of the mycelium to that of *Elaphomyces,* Heidenhain's iron alum haematoxylin used alone proved superior for the finer details of nuclear structure. The sections were in all cases cleared in clove oil, and in most cases this was followed by a treatment with cedar oil before passing them into xylol and mounting in balsam. The haematoxylin was applied in general

according to the schedule of Gwynne-Vaughan (Gwynne-Vaughan and Williamson, **20**) though for some stages shorter periods of staining were found to be adequate.

HOST RELATIONS

DeBary (**4**, **5**) has given a remarkable account of the phenomena attendant on infection, the formation and circulation of endogenously produced conidia in the "blood stream" and their germination to form sclerotia in the bodies of larvae of *Gastropacha Euphorbiae*, by the entomogenous species, *Cordyceps militaris*. Sopp (**39**) found that *C. norvegica* Sopp is normally a saprophyte on the forest floor, its parasitism on *Gastropacha Pini* being facultative. The results of his numerous inoculation experiments confirmed those of de Bary, e.g., that a given species of *Cordyceps* is not necessarily confined to a given species, genus or even group of insects. Lewton-Brain (**29**) reported the occurrence of the parasitic hyphae of *C. ophioglossoides* (Ehrh. Link (*C. parasitica* (Willd.) Seaver) in close contact with, and in some cases actually cemented to, the hyphae of *Elaphomyces*. In such cases a thin spot was apparent on the *Elaphomyces* hypha opposite the point of contact with the hypha of the parasite. Cells were likewise seen that had been penetrated by the parasite but no well-defined haustoria were seen. Lewton-Brain also reported the presence of isolated groups of cells of the host scattered about in the base of the clava of the parasite.

Within the base of the clava proper, in young clavae, the writer noted that the isolated groups of host cells were rather completely destroyed but in the surrounding areas the host cells were in various states of disorganization. In a few instances the hyphae of the parasite could be traced for considerable distances and in such cases a clearer picture of their activity could be formed. Although the point could not be conclusively proved with this material, there is considerable evidence that the *Cordyceps* mycelium is, in the early stages of its parasitism, an interhyphal parasite. A few favorable sections showed that narrow hyphae, much narrower than the parent hyphae, had penetrated the host cells (PLATE 29, FIG. 43). Whether these hyphae could be regarded as haustoria is, of course, open to debate. In such cases the cytoplasmic

contents of the host cells had not been completely destroyed. Other observations showed the mycelium of the parasite to be definitely intrahyphal, but in such cases the cytoplasmic contents of the host cells were almost or quite completely destroyed (PLATE 29, FIG. 45). Such a relation would be, if substantiated, entirely in keeping with the relation existing between many fungous parasites and their hosts.

Evidence indicates, likewise, that the clava of this species has its origin from numerous hyphae which arise as products of germination of certain cells of the pseudosclerotium situated just beneath the cortex of the *Elaphomyces* fruit body. This type of initiation has been described for *Claviceps purpurea* (Killian, **25**) and *C. microcephala* (Vincens, **45**). Also observations by the writer on the origin of the clavae of *Cordyceps clavulata* (Schw.) Ellis & Ev. show that in this species also the clava arises in the same manner as has been described above.[2] Should these observations prove to be correct in the case of *C. agariciformia*, Lewton-Brain's comparison of the base of the clava to the 'foot' of the *Anthoceros* or of the fern embryo, and his statement to the effect that the tissue of the host is destroyed and replaced by the "advancing 'foot' of the *Cordyceps*" are unwarranted. In the light, then, of evidence obtained from *Claviceps*, *Cordyceps clavulata*, various other entomogenous fungi (Petch, **35**; Massee, **31**; Cooke, **9**; Vincens, **43**) and indeed a majority of fungous parasites it is most probable that the parasite established its relation with the host long before clava formation began and has long since assimilated an abundance of food and stored it within the cells of its mycelium in preparation for its reproductive processes.

THE FORMATION AND STRUCTURE OF THE CLAVA

The earliest stages studied consisted of young clavae, a few millimeters long, which were sectioned longitudinally. Such sections showed very clearly that the emerging hyphae had ruptured the cortex of the host and in so doing had left groups of broken host cells scattered among the hyphae of the clava. Just how this rupture was accomplished is not known, but the evidence available indicates that the mechanics of the process are similar to that

[2] Paper to be published at a later date.

found in *C. clavulata*. In the latter, the hyphae arising from the germination of the sclerotial cells just beneath the integument of the host apply their tips against the cuticular covering and work their way through by dissolving a passageway or by mechanical pressure or by a combination of both processes. In other cases, individual hyphae emerge through natural openings in the cuticle. Though the hyphae emerge singly at first, they always emerge in definite groups so that the cuticular covering of the insect is riddled like a sieve at various points over its surface. Ultimately the continued pressure from the growth of other hyphae pushing up through these groups ruptures the cuticle at various points and the clavae emerge as cushion shaped structures, quite compactly organized toward the center, but of a loose, even floccose organization along the periphery. Bits of the cuticle which remain lodged among the hyphae of the clavae remain in the same relative position due to the predominant apical growth of the hyphae, so that later these fragments of cuticle are seen scattered among the hyphae at the base of the clavae.

In the young stages of *C. agariciformia*, the clava was composed of slightly larger and more compacted hyphae along the central axis. In sections of somewhat older specimens, ten to eleven millimeters long, this central region was composed of distinctly larger, longitudinally coursing hyphae intertwined with other very narrow ones. At the periphery, especially near the apex, the central region had given rise to a thin external layer of exceedingly fine and intricately interwoven hyphae which formed the outermost covering of the clava. In longitudinal sections of this stage, even prior to staining, the hyphae of the central region seem to form the skeleton that gives rigidity to the clava. Otherwise there was no differentiation of parts either as regards color or structure in the clavate, opaque head. This early differentiation was not noted in *C. militaris* (Varitchak, **41**).

It was at first thought that the fertile hyphae which ultimately initiate the perithecia might possibly be differentiated in the very young clava, even before emergence from the *Elaphomyces* fruit body. Accordingly, the younger stages of clava formation were all cut in median longitudinal sections, in the hope of finding fertile hyphae differentiated in the pseudosclerotium. Careful examina-

tion of all sections of this stage of development failed to give any evidence of such differentiation, nor could the hyphae from which the fertile hyphae arose during later stages of clava formation be traced for any considerable distance due to the interweaving of the hyphae with each other. These longitudinally cut sections were especially fortunate in another respect, however, for they showed the relative position, the relative time of origin and the relative rapidity of development of perithecia all in one section. Sections of clavae ranging from nine to twelve millimeters in length and which had become differentiated into a whitish-yellow stipe of about eight-tenths millimeter in diameter by two millimeters in length showed very well the above mentioned internal features. By the time the clava has reached this stage of external differentiation, the interior parts have likewise become highly differentiated. The structure of the stipe is somewhat more homogeneous than during the early stages of development due to the fact that the hyphae have become more uniform in size. One can, however, still distinguish hyphae which are broad in diameter intermixed with and partially obscured by hyphae which are smaller in diameter. The periphery of the stipe is covered by a thin layer of loosely interwoven, hyaline hyphae. By far the greatest amount of differentiation is evident in the head. The central portion of the head is composed of the same hyphal types found in the stipe, while the periphery of the head is covered by a dense layer of pigmented, rather closely interwoven hyphae of the same size as the finer ones of the stipe. This layer is very thin near the base of the head where it gradually merges into the peripheral layer of the stipe. It is thicker near the equatorial region and tends to remain of the same thickness on upward over the apex of the head. Between this peripheral layer and the central core of the head an intermediate zone of hyphae is readily distinguishable because of its looser, weft-like structure. All the hyphae composing this zone are at first of the same size as those of the peripheral layer but are hyaline and more loosely woven. The internal structure of the head of this species is therefore in agreement with that of *C. militaris* (Varitchak, **41**) except that no interzonal layer was distinguished in the latter species. A study of younger stages shows that both the pigmented peripheral layer

and the colorless, loosely woven interzonal layer between this and the core had their origin from hyphae of the core. The hyphae composing these three well-defined zones are septate and the cells are, for the most part, uninucleate.

THE ORIGIN AND DEVELOPMENT OF THE ASCOGONIUM AND RELATED STRUCTURES

The ascogonia originate as branches from various hyphae of the interzonal region. In a few instances these structures were found to have originated from hyphae of the peripheral layer and in a like number of cases there was evidence of their origin from hyphae within the periphery of the core. Ascogonia of *C. militaris* originate in the peripheral layer (Varitchak, **41**). The ascogonia, when first distinguishable, consist of short, usually slightly coiled, three to five septate hyphae, of uninucleate or binucleate cells. Unlike the aseptate ascogonia of *C. militaris* whose nucleus encloses a prominent nucleolus, these of *C. agariciformia* are distinguishable from the vegetative hyphae in their stages only by the fact that they are shorter, somewhat thicker, their nuclei stain more densely and they retain the stain more tenaciously than do the vegetative hyphae (PLATE 28, FIG. 1). In some instances, these structures arise in the larger interhyphal spaces of the interzonal region, and usually occur in groups of three to four. They were best seen in longitudinal sections of young clavae nine to twelve millimeters long. A careful study of the young heads throughout their entire length indicated that the first ascogonia arise near the equatorial region. A majority of the ascogonia found were below the equatorial region of the head, and a more or less complete series of developmental stages was to be noted as one examined the sections from the base up to the equatorial region. Thus, while ascogonia were being initiated in the basal portion of the head, sections through the equatorial region, and less markedly those in the apical region of the head, showed ascogenous hyphae beginning to appear in young perithecia. Development at the apex of the head is advanced beyond that at the base and that in the equatorial region is more advanced than either. These differences in degree of development of these regions were of great value in fixing the sequence of stages of development of

perithecia from the ascogonial stage up to the production of young ascogenous hyphae.

As the ascogonial cells increase in size they likewise tend to become more coiled and their cells become multinucleate. The nuclei, during these early stages of ascogonial development, were so small that positive identification of mitotic figures was not possible, yet the position of the nuclei seemed at times to indicate a recent division (PLATE 28, FIG. 2, 3). No antheridium-like structure was found in the vicinity of the ascogonia. Though two ascogonia often lay very close together, there was no evidence of union between them. This observation is in accord with the situation in *C. militaris* (Varitchak, **41**). The possible presence of pores through the cross septa of the individual ascogonia through which nuclear exchange might occur, structures of rather frequent occurrence among apogamous ascomycetes, will be discussed later.

Concurrent with the development described above certain fine, deeply staining hyphae, much resembling vegetative hyphae, become conspicuous by coiling about and interweaving among the ascogonia (PLATE 28, FIG. 4, 5). These complexes are the "pelotons" of Varitchak. It seems entirely possible that some of these interweaving and coiling hyphae originate from the same hyphae which earlier gave rise to ascogonia. It could be quite easily demonstrated that many of these coiling hyphae originated as branches from the surrounding vegetative hyphae. During the early stages of this process the enveloping hyphae form no particular pattern; very soon, however, these smaller hyphae have increased in number to form a small spherical envelope with the ascogonia at the base (PLATE 28, FIG. 5). Still later the young perithecial envelope consists of many loosely compacted hyphal layers. During this development of the wall of the perithecium certain cells of the ascogonia enlarge considerably and their nuclei increase in number. According to Varitchak (**41**) the ascogonia of *C. militaris* during comparable stages are aseptate, multinucleate structures, the bases of which become inflated to form sacs that give rise to the ascogenous hyphae. It is evident from this study of *C. agariciformia* that the ascogonia are septate structures and that not all the cells give rise to ascogenous hyphae.

Another point of difference between the early stages of perithecial formation in *C. militaris* and *C. agariciformia* is in the manner in which the interweaving vegetative hyphae separate the various enlarged cells of two or more ascogonia which are developing close together. This seemed to indicate that two or more perithecia might arise from a single group of ascogonia. This was found, however, to be the case only very rarely. As a rule, these separating partitions of vegetative were later pushed aside by the developing ascogonia so that only one perithecial cavity resulted. In a few cases the cavities of two perithecia were observed to be confluent during the ascogenous hyphae stage; still more rarely the cavities of mature perithecia were only incompletely separated

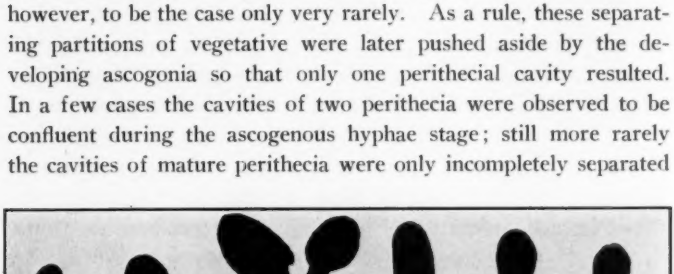

Fig. 1. Photograph of mature clavae attached to the host.

one from the other. These may either represent cases in which the separating hyphal partitions were not pushed aside until after they had been supplemented by others to form a distinct wall, or cases in which two perithecial primordia arose in close proximity to each other and in which, after their walls came in contact, these were displaced in part so that the cavities became partially confluent. Since the perithecia arise from a group of ascogonia, they may possibly prove to be always compound in origin.

DEVELOPMENT OF THE PERITHECIUM

One of the more striking features in the early stages of the perithecium is the development of its wall. Concurrent with the branching of the large cells of the ascogonia to form the primary ascogenous hyphae, to be discussed later, the spherical envelopes of loosely organized hyphal layers surrounding the ascogonia assume a definite polarity (PLATE 28, FIG. 6, 7). As the hyphae of this envelope increase in number the perithecial boundary opposite the ascogonia begins to elongate radially, i.e., toward the periphery of the head. For the sake of clarity in future discussion, this elongating side of the perithecium may be designated the ostiolar end, since the ostiolum will ultimately open there. By continued multiplication and growth of the hyphae of the walls, some of which may have originated from the ascogonia (Varitchak, **41**) and grown up to form the inner wall layer of the perithecium, a tension is exerted on the hyphae of the ostiolar end. The hyphae of this region whose tips had heretofore overlapped are progressively pulled apart (PLATE 28, FIG. 9, 12). Elongation of some hyphae keeps pace with the separation of others so that during the stages in question the developing ostiolum is always closed at its distal end. The hyphae which are pulled apart, together with other short hyphae which arose by the branching of those making up the innermost layer of the wall, fall back into the developing cavity. In such a stage the perithecial cavity is rather completely lined by hyphae with free tips.

Concurrent with the appearance of polarity in the perithecium, the large, multinucleate cells of the ascogonia begin to branch variously (PLATE 28, FIG. 6, 7), nuclei migrate fortuitously out into the branches and when these become septate, more than two nuclei are often found in some of the cells. These branches, the primary ascogenous hyphae, grow into the developing perithecial cavity. At this stage hyphae which have their origin in the wall layers are seen to have grown among the primary ascogenous hyphae and ultimately to have formed a partition of vegetative hyphae between these and their bases in the ascogonia (PLATE 28, FIG. 7). Finally, the old, more or less completely emptied ascogonial cells are almost completely hidden by the dense growth

of hyphae between and about them. This is contrary to the situation in *C. militaris* where the ascogonia tend to disappear very early (Varitchak, **41**). In other cases, perhaps just as typical, the ascogonial remains lie at the base, just beneath the floor of the perithecial cavity. At the level of the floor of the perithecial cavity some of the primary ascogenous hyphae multiply by branching and spread out along the floor of the perithecium, ultimately forming a layer of plectenchyma whose cells contain two to four nuclei (PLATE 28, FIG. 9, 13). These cells give rise to the true ascogenous hyphae, but due to their compactness and the presence of other hyphae it is impossible to state how many times a given ascogenous hypha branches before it gives rise to asci.

It is in sections of heads of about this stage that the cells of certain ascogonia are seen to be almost or quite emptied of protoplasmic contents. In certain favorably oriented sections of ascogonial cells, ruptures were noted through septa separating certain of these cells (PLATE 28, FIG. 10). An interpretation of these ruptures is difficult. The evidence in hand at present does not suggest any such sexual relation as has been described for *Polystigma rubrum* (Nienburg, **34**), *Epichloe typhina* (Vincens, **45**), *E. Bambusae* (Gaumann, **17**), *Ophiobolus graminis* (Jones, **24**), *Rhizina undulata* (Fitzpatrick, **16**), or *Ascobolus citrinus* (Schweizer, **37**). These ruptures were not observed in the younger ascogonia though they were sought for diligently. Their occurrence is due, in all probability, to mechanical injury by the closely investing hyphae, or else is the result of some tension caused by the growth of the parts about them. Even though no actual mitotic figures were seen, the multinucleate cells of the young ascogonia apparently result from ordinary mitotic divisions of the one or two nuclei originally present in each. Hence all the nuclei of a given ascogonial cell are believed to be daughter nuclei of the original nucleus or nuclei, rather than derived by the division of nuclei which have migrated from other cells of the ascogonium. This interpretation is in accord with that published for *C. militaris* (Varitchak, **41**).

Even while the perithecia are in this early stage of development the hyphae in the interzonal region show the effects of crowding and stretching. As the perithecia continue their development,

these interzonal hyphae became progressively more disorganized, until finally at maturity the entire layer of perithecia together with the peripheral zone may be peeled away from the central core quite readily.

DEVELOPMENT AND CYTOLOGY OF THE ASCUS

This critical phase in the development of the fungus merits especial consideration since it has received more attention by earlier investigators than have the phases thus far discussed. As has been stated earlier, the asci grow out from ascogenous hyphae which have in turn arisen from the plectenchymatous floor of the perithecial cavity. In some cases the asci arise from typical croziers (PLATE 28, FIG. 14), but intermediate conditions have been noted between these and cases where the asci arise as direct outgrowths of binucleate cells of the ascogenous hyphae (PLATE 28, FIG. 13). When this latter type of origin is frequent along a given ascogenous hypha the picture is like that figured; but probably wrongly interpreted, for *Epichloe typhina* (Vincens, **45**). Proliferation of croziers, as reported for *C. militaris,* were not observed nor were the ascogenous hyphae found to lose their contents and become amorphous as the asci matured (Varitchak, **41**). In all cases the ascogenous hyphae and young asci are extremely small, which, combined with the fact that these structures are compactly arranged in the perithecium, makes it difficult to identify all the variations present.

Regardless of how it originates, the young ascus is always binucleate (PLATE 28, FIG. 15). These two nuclei are indistinguishable. Both are very small and stain homogeneously. None were seen which, prior to fusion, showed a hyalosphere nor could a centrosome be satisfactorily demonstrated such as was described in *C. militaris* (Varitchak, **41**). These two nuclei approach each other and fuse before the young ascus has enlarged to twice its original length. The resulting primary ascus nucleus undergoes a considerable number of changes prior to its first division, all the details of which have not been heretofore published for any species of *Cordyceps.*

One of the more significant of these changes in the primary ascus nucleus is its enormous increase in size (PLATE 28, FIG.

16–26). Contrary to the situation in *C. militaris* (Varitchak, **41**), the nucleus loses its homogeniety very early in its development and one can then readily distinguish the nuclear membrane, nuclear sap, reticulum and a relatively very large nucleolus. Certain sections show a densely staining granule in contact with the periphery of the nuclear membrane (PLATE 28, FIG. 19). Similar and like staining granules have been called centrosomes (Bagchee, **3**; Varitchak, **41**). It could not be definitely ascertained whether this granule is extranuclear or intranuclear in origin. During the early stages of nuclear enlargement the immense nucleolus is encased by the reticulum, though it appears in all cases to be situated near the periphery of the nucleus (PLATE 28, FIG. 16). Later, as the nucleus prepares itself for division, the reticulum becomes organized into a definite spireme. As this structure becomes more thread-like it tends to pull itself away from the nucleolus to the opposite side of the nucleus and is connected with the nucleolus by only a thread or two. At about this stage the nuclear membrane becomes indistinct. During the development of the spireme the nucleolus is somewhat smaller in size, and at the same time very small, densely staining, chromatin-like granules can be observed in the equatorial region of the nucleus (PLATE 28, FIG. 25). Some of the spireme thread are distinct even during such a stage as this. Although the fate of the nucleolus could not be followed so completely as it was in *Pustularia bolarioides* Ramsb. by Bagschee (**3**), the evidence in hand indicates that this body undergoes fragmentation just prior to and during the early stages of the first division of the nucleus. During the period of its growth and reorganization prior to its first division the nucleus is located centrally in the ascus and occupies practically the entire width of it.

The stages of nuclear division seen most clearly during this study were metaphases or anaphases; only rarely was a telophase or intermediate phases evident (PLATE 29, FIG. 27a, 27, 29, 31). Compared with those of subsequent divisions the spindle of the primary division is quite long (PLATE 29, FIG. 27a). Though little claim to certainty is made, because of their small size, four chromosomes were counted in preparations which showed particularly good metaphase and early anaphase conditions (PLATE 29, FIG.

27a). It seems from this and the counts which will be given later for subsequent divisions that the somatic chromosome number for *C. agariciformia* is two Varitchak (**41**) states that two chromosomes were counted during the first division of the fusion nucleus, and later states definitely that the somatic chromosome number for *C. militaris* is two. During this first division, as likewise for the two succeeding divisions, a centrosome is apparent at each pole and is discoid to cap-shaped in form. The concave side of the centrosome is constantly adjacent to the spindle. Such a situation has been described by Jones (**24**) for *Ophiobolus graminis* Sacc. The elongated spindle is situated about centrally in the ascus and describes a wide arc, though it is not uncommonly an elongated S-shaped structure.

The two nuclei which reorganize from this division have a structure similar to the parent nucleus, differing from it principally in their smaller size and the absence of the large nucleolus; this structure being represented by two small, deeply staining, granules (PLATE 29, FIG. 28). In this respect these observations differ from those of Varitchak (**41**) who figures the interphase nuclei of *C. militaris* as homogeneous structures which lack both a reticulum and centrosomes. Judging from their size, internal structure and the infrequency with which these nuclei are found the second division must follow the first immediately. During all the nuclear divisions, except possibly the third, the cytoplasm is rather uniformly dense, though conspicuous vacuoles are present near the apex of the ascus.

The second division in the ascus is, as in other ascomycetes, a simultaneous division of the first two daughter nuclei. The form of the spindle differs little from that of the first division except in its somewhat smaller size (PLATE 29, FIG 29). During the late metaphase of this division four small chromosomes are apparent near the equatorial plate, and other figures of the early anaphase show two such deeply staining granules in transit to each pole. Evidence of astral rays extending from the centrosomes was seen in a few preparations, only. The definite, deeply staining spindle in most cases appears as a single line, though a truer picture of the spindle was sometimes seen. The spindle is so narrow that it is very difficult to demonstrate its individual

fibers (PLATE 29, FIG. 29). In fact, such fine cytological details are seen only when the differentiation of the stain is halted just at the right point during the process of destaining. This difficulty appears to be the rule rather than the exception in work with nuclei so small (Jones, **23**, **24**; Varitchak, **41**). The present writer was able to solve this difficulty in part, and at the same time insure entire asci for the study of later cytological phenomena, by making use of smears of asci which were stained and studied in toto.

The four nuclei which reorganize from this second division are similar to the parent nuclei except for their smaller size (PLATE 29, FIG. 30). Although there appears to be a longer interval between the second and third divisions than between the first and second, the nuclei do not increase in size appreciably nor reorganize as resting nuclei. The third division is likewise simultaneous and the spindles are predominantly parallel to or but slightly oblique to the long axis of the ascus (PLATE 29, FIG. 31, 32). A similar orientation of these spindles was found in *C. militaris* (Varitchak, **41**). Such an orientation of spindles results, of course, in a linear arrangement of the reorganizing nuclei. This arrangement seems particularly significant in connection with the form of the spores later to be organized about these eight nuclei.

The matter of how the filamentous, multiseptate, ascospores so characteristic of this genus are developed from the product of the third successive division of the fusion nucleus in the ascus has been the subject of diverse opinions (Lewton-Brain **29**; Faull, **14**; Maire, **30**; Varitchak, **41**). As Faull (**14**) has remarked, Lewton-Brain attempted a cytological investigation on *Cordyceps ophioglossoides* with material that was not properly fixed. In consequence he probably mistook nucleoli for nuclei. Although he figures no nuclear divisions, Lewton-Brain states that there is no evidence of spore delimitation in the ascus until after a great number of nuclei are present in it. Later, he says, these nuclei arrange themselves into eight rows and the cytoplasm about each row becomes delimited by longitudinal cleavages to form eight, multinucleate, aseptate spores; each of the spores becoming septate only after additional nuclear divisions. Faull (**14**) saw uni-

nucleate spores of the same species and thinks that the multinucleate spore probably arises from the uninucleate one by nuclear divisions accompanied by septation. Maire (**30**) found uninucleate spores in *C. agariciformia* but did not follow their development. Varitchak (**41**) in his work on *C. militaris* is in agreement with Faull.

The present writer finds that following the third division the cytoplasm about the eight reorganized nuclei cleaves to form an ascospore initial. No actual cleavage planes are noticeable until after the eight ascospore initials have completely reorganized, but even during the course of the third division the cytoplasm becomes particularly dense near the poles of the spindles. This condensation of cytoplasm continues until one can readily distinguish the symmetry of the young ascospore initials, even before cleavage planes are evident. A very careful study of the process of differentiation of the ascospore initials has failed to demonstrate that astral rays in any way initiate the cleavage of the cytoplasm during these stages. The spore initials seem rather to be first delimited by condensation of the cytoplasm about the nuclei followed by a series of small vacuoles which form and coalesce along the periphery of the spore initials, thus cleaving the cytoplasm. Later, after cytoplasmic cleavage has progressed considerably, astral-like rays can be demonstrated, in some preparations, emanating from a densely stained area at one end of the spore initial (PLATE 29, FIG. 37).

Thus from the evidence available, the mode of formation of the ascospore initials seems to accord rather with that described by Faull (**14**) and Jones (**23**, **24**) than with that described by Harper (**22**) and Varitchak (**41**). It should be noted, however, that the ascospore initials in *Cordyceps militaris* are delimited by astral rays, according to Varitchak.

The ascospore initials when differentiated, lie somewhat obliquely to the long axis of the ascus and tend to occupy the entire width of the ascus (PLATE 29, FIG. 34–36). Judging from the staining reactions of the boundaries of these structures as compared with the surrounding epiplasm—and later, as compared with the staining reactions of the boundaries of somewhat older stages

of these structures—no spore wall is formed about the spore initial, merely a cytoplasmic membrane (PLATE 29, FIG. 34).

As in *C. militaris* (Varitchak, **41**) the growth of these unicellular spore initials must take place extremely rapidly, for very few stages in their growth were found. In practically all stages seen, even the youngest, the nuclei were actively elongating indicating that the uninucleate spore initial stage is of short duration (PLATE 29, FIG. 34–39). In those stages found there was no appearance of cross septa until after the spore initial had grown considerably in length. Such a condition was described for *C. militaris,* but the suggestion was made that possibly the newly formed septa were difficult to stain. This explanation might suffice were it not that later cross septa are clearly evident, although the spores are elongating and nuclear divisions are still in progress. During the early growth of the spores the nuclei elongate greatly in such a manner as was described for *Rhytisma acerinum* (Jones, **23**). Just how they become organized again is not clear (PLATE 29, FIG. 39). Later the nuclei divide mitotically but the figures are too small to show any detail except at anaphase (PLATE 29, FIG. 40). At this stage the small deeply stained spindles, with a mass of chromatin at each pole, are quite conspicuous. Even after tranverse septa become apparent the spores continue to grow in length, each cell of the spore apparently being capable of independent elongation and division, though the terminal cells seemingly become inactive before the median ones do. The young spores are always eight in number and at maturity are thirty-five to fifty septate; each cell being uninucleate. Prior to being released from the ascus many spores break up into unicellular segments.

PECULIARITIES OF THE ASCUS

The development of the capitulum of the ascus first becomes noticeable as the primary ascus nucleus is preparing for its first division (PLATE 28, FIG. 19, 20). Such a stage shows the apex of the ascus somewhat enlarged and practically void of the granular contents so characteristic of the remainder of the ascus. Further differentiation proceeds rapidly so that by the time the three successive divisions of the nucleus have been accomplished the apical

portion of the ascus wall has become considerably thickened and a pore or core of clear cytoplasm is seen to extend up into the thickened area of the wall (PLATE 29, FIG. 33). At maturity, the apex of the ascus is covered by a much thickened, conical, lid-like process which is penetrated centrally by the narrow pore or ascostome. During the period in which the three successive primary nuclear divisions are accomplished the ascus has been increasing steadily in length, so that by the time the capitulum is completely formed the ascus has about reached its definitive length.

Another peculiar feature of the ascus, aside from certain deformities which perhaps never reach maturity or else become normal before they reach maturity, is due to the presence of crystals in it. These structures are quite evident in fresh material, and their effect is quite noticeable in sections prior to being stained. Apparently the various treatments through which the material was passed (fixation, dehydration, etc.) dissolved the crystals, but the distortion of walls and cytoplasm due to their presence were preserved (PLATE 29, FIG. 42). These crystals are noticeable, even in young asci, but as the asci approach maturity the distortion caused by the structures is quite pronounced. Often the ascus walls and even the spores are bulged to such an extent that rupture seems imminent. It is suggested that these crystals may play a rôle in liberation of the ascospores.

THE MATURE CLAVA AND PERITHECIUM

During the course of ascospore development, as described above, the clava has been steadily increasing in size. The length of the stipe seems to depend on the depth of the parasitized host under the soil, while the dimensions of the head are probably related to nutritional factors. The stipe is usually white to grayish-white in color while the head is greenish-black when the clava is mature (TEXT FIG. 1). Such mature heads, when placed under humid conditions, soon become covered by a hyaline, viscous mass of spore segments and almost complete spores. These spore segments swell considerably and often germinate while still in contact with the clava. On nutrient medium these germinating spore segments form abundant conidia resembling the form genus *Spicaria*.

The mature perithecium is ovate to pear-shaped in form, its broad base resting in the much weakened and distorted interzonal area and its long neck protruding through the pigmented peripheral layer to the outside. So evenly do the hyphae of the neck fit into those of the peripheral layer that, as suggested by Lewton-Brain (**29**), the perithecia appear on superficial examination with low magnifications as invaginations of the peripheral layer. At maturity the perithecial cavity is completely filled with asci in all stages of development. The paraphyses-like hyphae together with the hyphae which were dislocated during ostiolar development have gelatinized and disappeared for the most part, in all probability being used as food by the developing asci or else as an osmotic fluid during the enlargement of the perithecium. At the base of the perithecium may be found the asci which have emptied and collapsed, thus making room for a new crop of asci originating from the still active ascogenous hyphae. It is not know how long a perithecium continues to produce spores, but it is conceivable that the active ascogenous hyphae may continue to produce new asci and spores for weeks. The exterior walls of the mature perithecium, at its base, are very nearly in contact with those of the adjacent perithecia. The walls have, throughout, lost their plectenchymatous structure, being now pseudoparenchymatous. The ostiolum, which is now continuous and open from the perithecial cavity to the outside, is lined with deeply staining periphyses which have arisen from the walls of the ostiolum. Scattered among the asci and often in the ostiolum (they were for the most part washed away) are many complete spores, but for the most part the spores have broken at the cross septa to form spore segments.

SUMMARY

1. This investigation consists of a study of the development of *Cordyceps agariciformia* (Bolt.) Seaver from the initiation of the clava until the spores mature.

2. This species begins its parasitism as an interhyphal parasite, but soon invades the hyphae of its host, *Elaphomyces,* and becomes an intracellular parasite.

3. Apparently the clava is formed after the parasite has com-

pleted the absorption of food from its host, and is initiated by hyphae which have arisen from the germination of pseudosclerotial cells lying just beneath the cortex of the host.

4. The young clava consists of a mass of hyphae, the central ones being somewhat larger in diameter and somewhat more compacted than the peripheral ones. Very early, however, the stipe becomes differentiated externally into a stipe and head.

5. Internally, the stipe consists of (1) a central core of compact, hyaline hyphae of two sizes which run predominantly parallel to the long axis of the clava and (2) a peripheral layer of fine, hyaline, loosely interwoven hyphae. The head consists of (1) a central core, which structurally is a continuation of the core of the stipe, (2) a peripheral layer of fine, pigmented and intricately interwoven hpyhae, and (3) an interzonal region of hyaline, loosely woven hyphae, of the same diameter as those of the peripheral layer.

6. The ascogonia arise predominantly within the interzonal region in groups of three to four as somewhat enlarged hyphae, each three to five celled. Certain cells of these structures rapidly enlarge and become multinucleate. No evidence of an antheridial structure was seen.

7. Fine, densely staining hyphae coil about and enclose the ascogonia and thus initiate the formation of perithecia.

8. The perithecial primordium is, during its earlier stages, more or less globular but soon the enveloping hyphae assume a polarity of growth and the true wall and ostiolum are formed.

9. Later the multinucleate cells of the ascogonium branch to form primary ascogenous hyphae. These hyphae elongate to form a plectenchymatous layer of binucleate cells along the floor of the perithecial cavity, which in turn give rise to the true ascogenous hyphae.

10. The ascus arises either from a crozier or as a direct outgrowth of a binucleate cell of an ascogenous hypha.

11. The cytology of the ascus and spores has been studied in considerable detail. The ascospore initials arise by vacuolar cleavage rather through the activity of astral rays. These structures are at first unicellular and uninucleate, but very soon elongate to form the mature, multiseptate spore. A septum is not formed

until after the spore initial has attained considerable length. Even after septa begin to form, the spores continue to increase in length by means of independent elongation and division of its cells, until at maturity the spore is thirty-five to fifty septate.

12. The somatic number of chromosomes for this species is two.

ACKNOWLEDGMENTS

In conclusion, I wish to express my deep feeling of gratitude to Doctor Duncan S. Johnson under whose direction this study was accomplished. His unfailing kindness and invaluable suggestions during the course of this study, and particularly in preparation of the original manuscript, have, in a very real sense, made the completion of this work possible.

I also wish to acknowledge my deep obligation to Doctor G. F. Weber of the University of Florida Agricultural Experiment Station, Gainesville, Florida for his kindness in sending me material of *Cordyceps agariciformia;* and to Doctor A. S. Rhoades of the University of Florida station at Cocoa, Florida for like material and also for an excellent photograph of these specimens. Likewise, I wish to acknowledge the kindness and suggestions of Doctor F. A. Wolf of Duke University during the course of this revision.

EXPERIMENT, GEORGIA.

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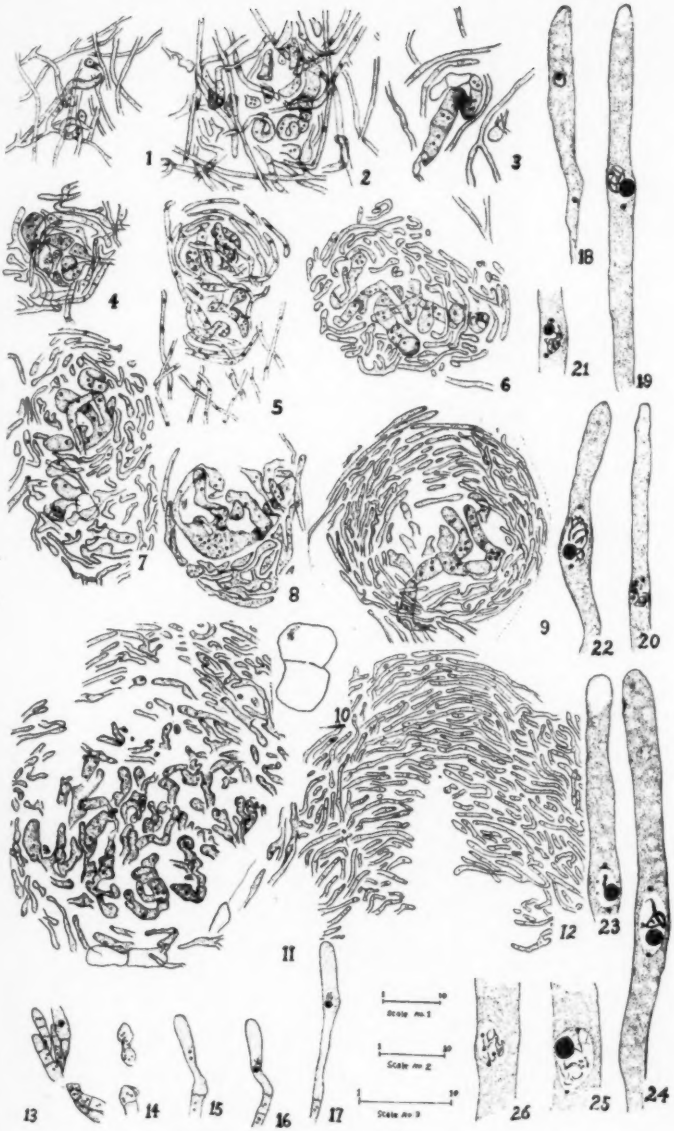
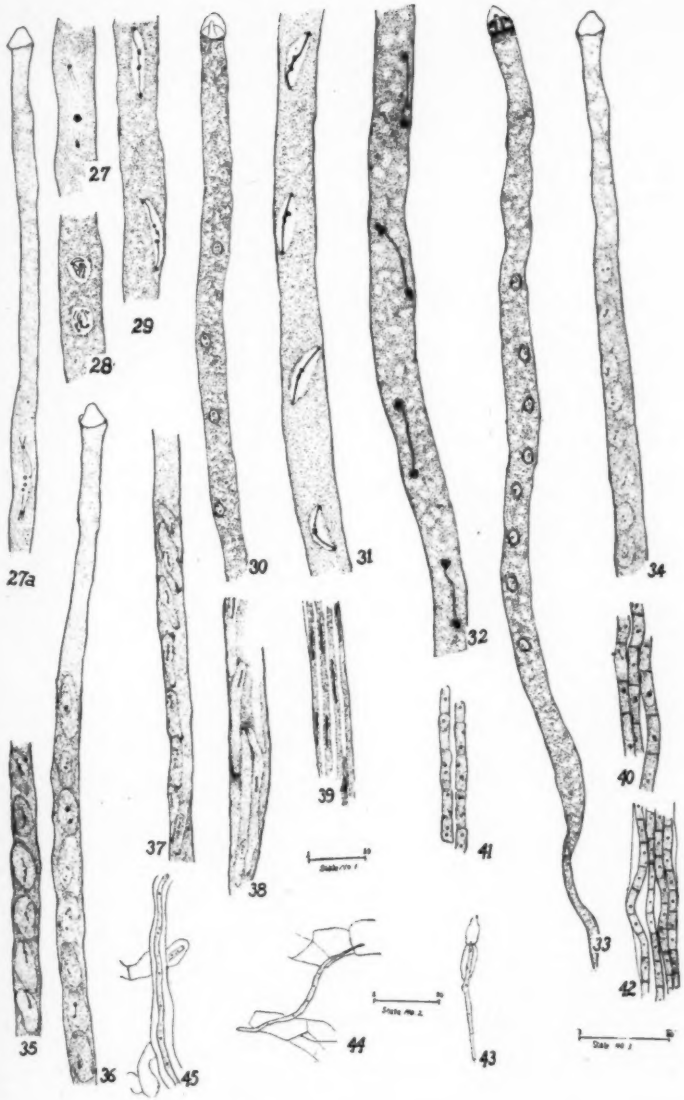
EXPLANATION OF PLATES

PLATE 28

All figures drawn with the aid of an Abbe camera lucida (Zeiss). Scale 1 Zeiss 3 mm. Apochr. immersion lens (N. A. I. 40) with Zeiss 20 × comp. ocular. Scale 2 Leitz 1/12 immersion lens (N. A. I. 30) with Leitz 15 × periplan ocular. Fig. 1, 4, 5, 8, 10, 11, 12 drawn to Scale 1, others to Scale 2. Fig. 1, A group of young ascogonia which are slightly larger and stain more deeply than the surrounding vegetative hyphae; 2, Somewhat older ascogonia, showing a distinct coiling and enlargement; 3, A single ascogonium showing enlargement of certain of its cells; 4, Ascogonia in which certain cells have become multinucleate. Note enveloping hyphae; 5, Portions of ascogonia whose tips overlie each other, though there is no evidence of connections between them; 6, A group of ascogonia showing certain cells that are beginning to branch; 7, A more advanced stage than the preceding showing a few of the partition hyphae about the equatorial region; 8, Portion of an ascogonium showing manner of branching of much enlarged, multinucleate, ascogonial cells; 9, An obliquely cut section showing a few primary ascogenous hyphae in the young perithecial cavity; 10, Two, much enlarged, empty, ascogonial cells taken from the base of a young perithecium bearing ascogenous hyphae. A rupture in the septum is evident. 11, Semi-diagrammatic sketch of the interior of a young perithecium. The variety



CORDYCEPS AGARICIFORMIA



CORDYCEPS AGARICIFORMIA

in structure of the ascogenous hyphae is striking. 12, Apex of a young perithecium showing the mode of formation of perithecial wall and ostiolum. Fig. 13, 14, 15, 16, 17, 20, 21, drawn to Scale 1; Fig. 18, 23, drawn to Scale 2; others to Scale 3. Fig. 13, Portion of the plectenchyma of the floor of a young perithecium, showing asci arising directly from binucleate ascogenous hyphae; 14, Two views of croziers found at the base of a young perithecium; 15, A young, binucleate ascus; 16–26, A series showing the growth of the ascus and progress of nuclear changes prior to the first division. The polar granules present in each case are interpreted as centrosomes. Fig. 19, 20, 23, beginning of operculum formation.

PLATE 29

All figures drawn with the aid of an Abbe camera lucida (Zeiss). Scales as in Plate *28*. Fig. 27a, 30, 34–45, drawn to Scale 1, others drawn to Scale 3. Fig. 27a and 27, First division of the primary ascus nucleus at early anaphase and metaphase respectively. 28, A binucleate ascus, the nuclei preparing for the second division; 29, Division figure of the second mitosis. Due to their small size, the behavior of the chromosomes at metaphase could not be ascertained. 30, A four nucleate ascus, the nuclei preparing for the third successive division; 31–32, Division of the third nuclear division, fig. 31 showing chromosomes, fig. 32 showing a late anaphase condition; 33, An eight nucleate ascus; 34–42, The organization of the spore initials and the growth of these to mature spores in order of sequence. Fig. 34, In preparations of this stage the activity of astral rays could not be detected. Fig. 35, The nucleus is shown elongating to the periphery of the spore initial. Fig. 37, Shows the crescent-shaped centrosome-like body at the basal pole of the elongating spore initial. Fig. 39, Elongated nuclei in young spores. Fig. 40–41, Nuclear division in cells of young spores. Fig. 42, Distortion of spores and ascus wall caused by crystals; Fig. 43–45, Illustrating certain phases of the host relations. Fig. 43, An intracellular hypha has pushed an attenuated tip into the adjoining host cell. Fig. 44–45, Intracellular hyphae of the parasite.

FURTHER TESTS FOR HORMONE ACTION IN NEUROSPORA

ALICE ARONESCU

(WITH PLATE 30)

The recent note in Science by Plumb and Durell (**1933**) reporting the effect of the female hormone theelin on preventing or delaying the formation of zygospores by *Rhizopus nigricans* reminds us again that some such means may be a valuable aid in determining whether the mating of two strains of a heterothallic fungus is a matter of *sexual* reproduction. This is of especial interest in view of the unusual results previously reported by Moreau-Moruzi (**1931**) on experiments dealing with the nature of the stimulant which induces the formation of perithecia with asci in the heterothallic species *Neurospora sitophila.* Two strains of opposite mating reaction were cultivated, one in each arm of U-tube cultures. The authors state that perithecia formed on one of the agar surfaces, as a result of diffusion of something analogous to hormones from one of the mycelia to the other some distance away. These perithecia matured without intimate contact between the two mycelia and without an exchange of nuclei or any act of copulation. Later (**1932**) they inoculated a petri dish culture, for example, on one side with strain 17, and on the other side with a strain of opposite reaction. They did not obtain perithecia along the line where the two mycelia came into contact, but they were formed on either side of this region and at a certain distance away from it. Their interpretation is the same as before, namely, perithecia were formed as the result of an action taking place between the two strains at a distance.

Experiments along this line were undertaken by Dodge (**1931**) who repeated in substance the work done by the French authors. He was unable to find any evidence of hormone action. In each case where perithecia were formed, they were produced, he says, as a result of the coming into contact of the two strains of opposite sex reaction.

The writer (**1933**) continued the experiments trying to determine through another method, what it is that induces the formation of mature perithecia with asci. In interpreting the results, we relied on two important facts, found by Dodge: (*a*) the mendelian segregation of the factors for conidial and sex characters (**1930**); (*b*) the regularity with which perithecia are obtained in every case in which one spermatizes or conidiates incipient perithecia, "sclerotia," of one strain with spermatia or conidia of the opposite "sex" (**1932**, **1933**) showing that between the strains there is an actual exchange and fusion of nuclei.

In a recent paper (**1933**) the writer has shown that if we assume the perithecia in U-tubes matured as a result of the action of diffusible hormones, the results obtained after germinating the eight spores of an ascus should be entirely different from those obtained if a fusion of nuclei derived from the two strains employed had taken place. No case has yet been found in which such hormones transmit and imprint hereditary factors. One suspects that their action is, at most, of secondary importance, an action which accompanies the principal act of copulation. In this case, the eight spores of an ascus from a perithecium obtained in the manner described by Moreau-Moruzi, should give, after germination, eight strains absolutely like the particular strain cultivated in the arm where the perithecia finally appeared.

In the paper mentioned above we reported having analyzed the perithecia formed in the connecting arms of eight U-tubes, where two mycelia, one albinistic and the other conidial, of opposite reaction, were grown. From an analysis of over fifty asci from different perithecia, we found that in each case the segregation for conidial and "sex" factors had occurred in a perfectly normal mendelian manner, as would have been expected, considering that a fusion of nuclei from the two mycelia that formed these perithecia had taken place.

The only objection that could be made against the experiments reported was that strains exactly identical to those employed by Moreau and Moruzi in France had not been used. They used a strain referred to as "Souche de Bordeaux" found by one of the authors (Moruzi, **1932**) on mushrooms. With this strain they grew a strain of American origin. Considering it possible that

the Bordeaux strain, while it might be identical, morphologically, with the American strain, yet might, nevertheless, behave differently physiologically, we asked Professor Moreau to send us this particular strain. This he was very glad to do, and through his courtesy new experiments were possible. The results obtained are here reported. In order to obviate any confusion it should be noted, however, that the Bordeaux strain when crossed with our A and B tester strains proved to be of "sex" A and not of "sex" B as indicated in all the publications by Moreau and Moruzi.

Three series of cultures in U-tubes were made in December, February and April. In all cases we inoculated one arm of the U-tube with the Bordeaux strain and the other arm with some one of the four "sex" B strains from ascus 56,[1] namely 56.1, 56.2 (non-conidial), 56.3 and 56.4 (conidial). Each combination of cultures was twice repeated in each series, so that every series consisted of eight U-tubes.

We muse state, in passing, that the way in which the growth of the mycelia develops towards the connecting arm, as well as the drying out of the agar and the appearance of air pockets (Dodge, **1931**) depend to a large extent upon the way in which the medium is prepared. A small variation in the concentration of the medium, or a slightly prolonged sterilization may bring about a hastening of drying out of the agar in the two arms, which gives different and very interesting aspects to the developments in the tubes.

The U-tubes of the first series were inoculated on December 12, 1932. With a magnifying glass we were able to follow in each case the growth of the two mycelia towards the connecting arm and mark their progress with a colored pencil each day. All of the tubes presented, in general, the same aspects. By December 19, that is, at the end of not more than seven days, the pairs of mycelia in each U-tube had come together in the connecting arm. The drying out of the agar started very soon after the inoculation, so that in the interval from December 19 to December 29 the air pockets completely united in the middle arm, provided the oxygen for the formation of perithecia in this region. In two cases the

[1] See Mycologia **22**: 1930 for full account of cultures from ascus no. 56.

perithecia advanced from the middle of the connecting tube towards one of the arms and in one case they even reached to the surface of the agar in the arm with the 56.2 strain (PLATE 30). In not a single instance were perithecia obtained first on the agar surface or before the two mycelia came in contact with each other.

As compared with Dodge's experiments, the advance of the mycelium, down through the agar, the formation of the air pockets, and the formation of perithecia was accomplished in a very short interval of time. It could be claimed that, because of this rapid development, the hormones did not have time enough to diffuse through the agar and thus induce the formation of perithecia at a distance. In order to prevent this drying out, two other series of experiments were performed. In one case we prepared a series of tubes in a way to avoid as far as possible accidental contamination. In the case of the conidial strains we started from single spore (conidium) cultures. In order to prevent drying, the tubes were placed under a bell jar which was kept moist with water-soaked filter paper placed on the inside. The bell jar as well as the glass plate on which the basket with the U-tubes was placed were disinfected with either alcohol or bichloride of mercury every time the jar was removed to observe the progress of the mycelia. The cotton plugs were thoroughly sprayed with alcohol as an additional precaution.

In six of the tubes the mycelia came very close together in from five to seven days. In two other tubes they remained separated at an appreciable distance. Only after one full month did one of the tubes begin to dry out. The remainder of the tubes did not begin to form air pockets until two or three months after the inoculation. The drying continued at a slow pace, the joining of the air pockets varying with each tube. After from five to seven days from the time the air pockets came together in the connecting arm, perithecia appeared near the point of contact of the two mycelia, and progressed thereafter toward each of the two arms. In two of the tubes the fusion of the air pockets was accomplished only four months after inoculation. Possibly, by this time, the mycelia were too old to start a new growth and no perithecia were formed. In this case as well as in the preceding series of cultures, perithecia did not appear at the surface of the agar but only in the connect-

ing arm and then only after the two opposite strains came into contact in the presence of air.

In the case of the second set of experiments, made for the purpose of preventing the agar from drying out, instead of placing the U-tube under a bell jar, water was introduced into the arm just as soon as the air pockets began to form, which was on the third day after inoculation. Even though precautions were taken in introducing the water, the operation afforded in two cases an opportunity for contamination by the conidia which are very light and float in the air. In two of the tubes a few perithecia developed on the agar surface. The analysis of segregations in seven asci from five different perithecia as well as the fact that perithecia appeared just five days after introducing the water, proved conclusively that the perithecia were matured as the result of accidental contamination. This merely illustrates that one cannot be too careful in culturing *Neurospora*, and it can be said that in all of our other experiments when the plugs were not removed, no perithecia were formed on the surface of the agar in either of the arms of the U-tubes.

We did not always find, like Dodge (**1931**), that the drying out occurs first in the arm with the conidial strain. The numerous variations obtained led us to believe that it may be largely a matter of chance or that it may depend upon the abundance of mycelia present, be it albinistic or conidial or the relative tightness of the cotton plugs in the opposite arms and other factors.

Denny (**1933**) has measured the oxygen requirement of *N. sitophila* for the formation of perithecia and has found that, at room temperature, the lowest oxygen concentration at which perithecia formed readily was about 1 to 2 per cent by volume. Reducing the oxygen below 0.5 per cent the formation of perithecia was inhibited.

Recently, we have used methylen blue in our agar medium as an indicator for the amount of oxygen present in the agar. The agar is colored light blue by adding a few drops from a very dilute solution of this substance, before sterilizing. If the inoculated tubes are kept in moist condition so as to avoid immediate drying out of the agar, the fungus, by growing through the medium, consumes oxygen, reduces the methylen blue and by the time the

mycelia arrive in the connecting arm, the agar loses much of its blue color. As soon as the air pockets begin to form, the indicator, by oxidation, gradually regains its blue color and marks therefore, the presence of a new supply of oxygen in the agar. It is also very interesting to note that this substance does not seem to hinder the growth of the fungus and that perithecia develop, in the connecting arm, in the usual manner. This was true even for concentrated solutions.

A last attempt to check the possibility of hormone action as the main factor in the production of mature perithecia, was made with petri dish cultures. Moreau and Moruzi (**1933**) inoculated pairs of strains of the same reaction at two opposite sides of a petri dish. They obtain, among numerous big "sclerotia," also mature perithecia with asci. They maintain that when a culture is inoculated on opposite sides or in two different places with the same strain, the production of large sclerotia such as are never found, they say, in cultures started from a single inoculation, is induced. This stimulation, according to them, goes so far in a few cases as to lead to the formation of mature perithecia. This would mean that each strain has all of the potentialities sexually as well as morphologically, and that heterothallism is merely of secondary importance in securing a greater abundance of perithecia.

We repeated their experiments with a few strains obtained from different sources, namely, Wolf, Wittrock, 56.1, 56.2, 56.3, 56.4, all of which are "sex" B; and also Bordeaux strain, 56.5, 56.6, 56.7, 56.8, which are "sex" A.

All possible combinations were made between strains of the *same* "sex" and each combination was made in triplicate. In order to prevent any possible contamination, we started, in the case of the conidial strains, from single spore cultures. The petri dishes were thereafter kept in an incubator and were sprayed occasionally with bichloride of mercury. During an entire month, the sclerotia that showed a more pronounced development were examined from time to time with a binocular through the upper cover. After this interval, about one hundred of these bodies were crushed, mounted and observed under the microscope, but none of them showed any asci. We have never in any of our cultures derived from single normal spore strains of heterothallic species, obtained perithecia with *asci*.

Our U-tube experiments, repeated in three series, fully convince us that in all cases where perithecia were obtained they were the result of the contact between strains of opposite mating reactions.

Theoretically, in the case of the *Neurospora,* we do not exclude, other necessary conditions being right, the possibility of having perithecia develop *more readily* under the influence of a stimulant such as described by Moreau and Moruzi. Many cases are known in the literature for different fungi when the presence of colonies of bacteria or other entirely different fungi so change the environment as to induce ascocarp formation.

In 1903, Molliard claims that the only way to obtain ascocarps in pure cultures of *Ascobolus furfuraceus* is to inoculate that culture with a bacterium which was first isolated from contaminated cultures of this fungus. Recent work done by Dowding (**1931**) shows that this species is heterothallic and that apothecia can be obtained in perfectly pure cultures if the two opposite strains are grown together. The bacteria might help nevertheless to bring about the right conditions in the medium for the formation of perithecia provided both of the strains were present.

Heald and Pool (**1909**), Dodge (**1912**), Sartory (**1912, 1916, 1920**) and McCormick (**1925**) have also shown that the introduction of colonies of certain bacteria or certain species of fungi, frequently induces ascocarp formation in cultures that otherwise would have remained sterile.

Our cultures inoculated with two strains of the same mating reaction show, from time to time, large sclerotia, but never any mature perithecia with asci. These large sterile bodies appear just as frequently in cultures inoculated with only one strain.

If the formation of perithecia in *Neurospora* may sometimes be the result of only a nutrition or a hormone stimulus, and not of a fertilization process ending in fusion between nuclei, the writer is of the opinion that, in such cases, the final proof that the cultures had or had not been contaminated must rest with an analysis of the eight cultures to be obtained from individual asci. This would show in case of hormones or nutritive action alone, all of the cultures to be alike as to sex reaction and conidial characters.

THE NEW YORK BOTANICAL GARDEN.

EXPLANATION OF PLATE 30

Neurospora sitophila

A. U-tube culture (inoculated December 12) with the Bordeaux strain, B. s., growing in the right arm, and strain 56.4 in the left arm. Photograph taken twenty days later. The air pockets had met at the center of the connecting arm a few days previously. Perithecia soon began to develop progressing toward the arm containing strain 56.4.

B. The same type of culture except that the albino non-conidial strain, 56.2, was grown in the left arm of the U-tube. Here, after the air pockets had met, the mycelium of the Bordeaux strain advanced along the wall of the left arm of the tube so that perithecia, starting from the bottom, developed all along up to the agar surface of the 56.2 arm.

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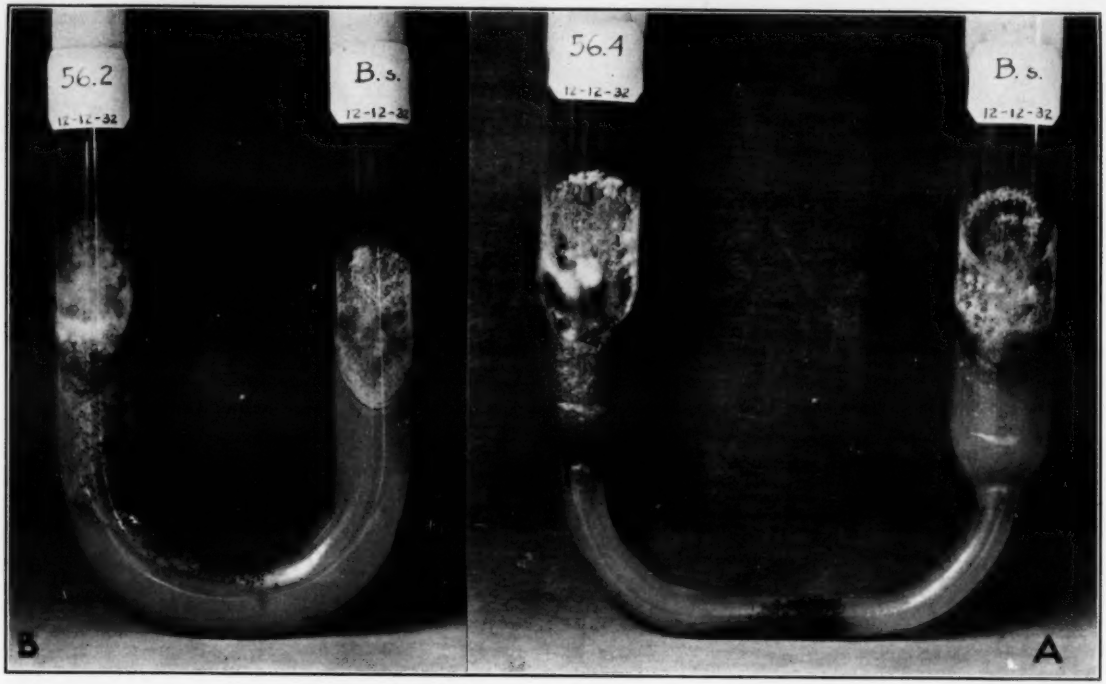


NEUROSPORA SITOPHILA

NEW AND INTERESTING FUNGI

H. C. Beardslee

(with 3 text figures)

During the past year, it has been the good fortune of the writer to collect and study several species of fleshy fungi which seem to be of unusual interest, and the following notes in regard to them have been prepared in the hope that they may be of service to other students of these plants.

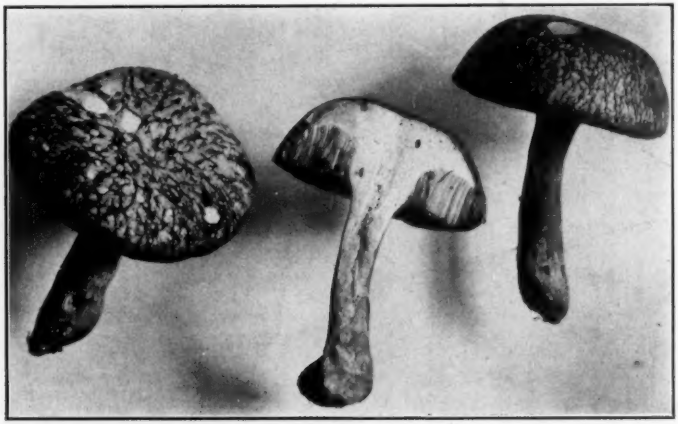
Tylopilus conicus (Rav.) comb. nov.

One of the greatest thrills of the season was the discovery, in Florida, of this long lost species. It was discovered and described in 1853 by Ravenel, who found it in "damp pine woods" in South Carolina, and its characters are so striking that in spite of the fact that it does not seem to have been reported since his day, it is still retained in our literature, Peck in "Boleti of the United States," and Murrill in North American Flora both listing it.

When found it was at once recognized as one of the "pink-spored" Boleti but it was not one of the five species with which I was familiar and my scanty winter library had nothing which dealt with Boleti. A specimen and colored photograph were, however, sent to Mr. L. C. C. Krieger who pronounced it Ravenel's species, and subsequent study seems to confirm this determination.

As will be seen from the figure of our plant, its appearance is very striking. The pileus is covered everywhere with appressed yellow fibers forming a coarse network, whose bright yellow color is very striking against the white surface of the cap. No species of *Boletus* known to me at all resembles it. The tubes are flesh color with their mouths round and .4–.7 mm. in diameter. The stipe is slender 4–5 cm. long and 8–12 mm. in diameter. The

spores were 15–18 by 6–7 mc. A good spore-print was obtained, and was distinctly pink, but rather darker than the spores of some of this group. Their color indicated that the species belongs in *Tylopilus* rather than in *Ceriomyces*.



Tylopilus conicus

Plants were found in two different stations, in both cases in cut-over pine woods. It may prove to be not rare in Florida.

CHAMAEOTA PUSILLA PAT.

The genus *Chamaeota* is of peculiar interest to all mycologists. It can be recognized at sight by its pink spores and its annulate stipe, but its species are so few in number (only about a dozen in all!) and so rare in occurrence that few collectors have ever seen a living specimen. Ricken does not list any species for Germany; Rea gives two for England but has never seen either of them, and only two species have been found in the United States, each reported from one station in Michigan.

Under these conditions it can easily be understood that it was with peculiar pleasure that what seems to be *C. pusilla* Pat. was found near Oviedo, Florida, in December.

Our plant was small, with the pileus 1.5 cm. broad, and lemon yellow streaked with dark brown fibers, which were most abund-

ant at the center. It had a distinct annulus, but one of an unusual character, which does not seem to have been sufficiently emphasized. The basal third of the stipe had a fibrous sheath, which was yellow and apparently continuous with the epidermis of the pileus. The pileus had broken away from this, leaving a distinct ring on the stipe. Both the annulus and the base of the stipe were yellow, while the stipe above the annulus was white. The spores were sub-globose to globose, 5–7 × 5 mc.

As to the identity of our plant it is difficult to speak with finality. Mr. Alexander Smith of the University of Michigan has kindly compared my material with the specimens and figures of the two Michigan species. *C. sphaerospora* Peck seems to be amply distinct from our plant. *C. mammillata* Longyear which was found near Greenfield, Michigan, corresponds well in form and size and in microscopic characters. The pileus is however described as having a "prominent mammiform projection" and as being white with a lemon yellow umbo, and the stipe is not described as sheathed, with a yellow base.

The Florida plant when growing was round-campanulate and obtuse, but in drying it developed a marked umbo. It is also to be noted that while Longyear does not speak of the stipe as being sheathed, his figure indicates a sheath quite distinctly, and since the sheath is continuous with the surface of the pileus, if the pileus is white the annulus and base of the stipe would of necessity be white. It would seem possible that our plant should be considered a form of Longyear's species with the pileus yellow instead of white.

Among the European species *Annularia* (or *Chamaeota*) *Fenzlii* and *A. pusilla* Pat. (Bull. Soc. Myc. Fr. **4**: 24, 1888) which is described as a "miniature *A. Fenzlii*" seem close to our plant. Gillet's figure of the first species shows a plant differing from ours only in size. It has the same yellow color, same rounded pileus, and the same stipe, white above and yellow-sheathed below, but its size is more than twice as large. *A. pusilla*, however, seems very close to our species. The stipe is said to be yellow, instead of white above and yellow at the base, but otherwise both figure and description fit well.

For the present it seems best to consider our plant *C. pusilla*

Pat. It is questionable whether *C. mammillata* Long and *C. pusilla* Pat. would not best be considered forms of *C. Fenzlii* as there is little save color and size to distinguish them, and color and size are notoriously unreliable characters. This time must decide, but in the meantime we have at least a new American station for this rare genus.

PLUTEUS COCCINEUS MASSEE.

Syn. *P. caloceps* Atkinson, *P. leoninus* Fries var. *coccineus* Massee.

This species is not only of surpasing beauty, but is also exceedingly rare, and on that account has been observed with great interest in a new station at Perry, Ohio. For several years it has appeared there on a lesion in the same red maple. The mycelium is without doubt well established in the diseased wood of this tree, but repeated search has failed to detect it on any other tree or in any other station.

It is certainly one of our most striking species. No agaric has more brilliant colors. Lange has recently collected and studied it in Denmark and considers it the same as Atkinson's *P. caloceps*. This conclusion seems to be reasonable, but study of our plant, and also of true *P. leoninus* Fries leads me to doubt the propriety of considering this brilliant plant a color form of *P. leoninus*. For reasons given below, it seems clearly distinct and to merit its own specific name.

Peck's keen eye early observed that the genus *Pluteus* can easily be separated into two sections by the nature of the surface of the pileus. One section has a silky appearance, and is more or less fibrillose, and the other has a "micaceous appearance" and is glabrous. Apparently he did not examine the cuticle of the two groups with a microscope, for he does not make clear the structural difference upon which the difference in appearance depends. Lange made this clear. In the first group the surface is made up of long interwoven hyphae whose pointed ends are sometimes more or less free so that the pileus is fibrillose, and sometimes wholly appressed so that the pileus is glabrous. In the other section the surface is made up of rounded cells, so that under moderate magnification it has the appearance of a cobble-stone

pavement. Under a microscope the difference is quite striking.

Pluteus leoninus Fries seems to be northern in its distribution. Kauffman reports it only from the "northern hemlock woods" of Michigan. Peck found it in the Adirondacks, and I have seen it only in Canada. It is lemon yellow but is larger than our common yellow species *P. admirabilis* Peck and has a solid stipe and silky pileus. When examined under the microscope the true species has the surface of the pileus made up of slender, interwoven hyphae exactly as Patouillard states. The scarlet plant, however, has the surface made up of rounded cells or in other words belongs to the micaceous section exactly as Lange has stated. The difference is plain to the naked eye, but under the microscope it is striking.

The scarlet *Pluteus*, then, differs from *P. leoninus* Fries not only in its color, but also in the structure of the epidermis of the pileus and is more closely related to *P. admirabilis* Peck and *P. sororiata* Karst. than to *P. leoninus* Fries. I believe it should be considered distinct under the name *P. coccineus* Massee. Apparently few botanists have seen both of these species living, which accounts for the confusion.

Mycena glutinosa sp. nov.

Pileo sub-membranaceo, campanulato-convexo, disco demum depresso, striatulato, glabro, viscoso, pellicula gelatinosa, secernibili tecto, albo; stipite albo, glutinoso, pellicula secernibili tecto, basi fibrilloso; Lamellis albis, angustis, non confertis, adnatis demum decurrentibus.

Pileus 1–3 cm. latus. Stipes 6–8 cm. longus. Sporae ellipsoideae 6–8 × 3.5–4 μ. Ad truncos, dense caespitosa Oviedo Fla. Cystidia, rara, parva, acuta.

This seems to be a very distinct species. It was found at Oviedo Fla., growing in dense masses on old logs. The plants are pure white and both pileus and stipe are very viscid, and both have a tough, gelatinous cuticle, which can easily be stripped off entire. The pileus is convex, and striatulate to the depressed center. The lamellae appear adnate at first but soon seem more or less arcuate decurrent. It could easily be considered an *Omphalia*, but in-so-much as several species of *Mycena* which are closely related to this plant are abnormal for *Mycena* in the same way it has seemed best to place this species with them.

Among a number of interesting species of *Russula* was one which was especially puzzling. Its appearance will be readily understood when it is said that it resembles *R. variata* Banning so closely in its narrow, crowded and forking gills, and in the blended colors of the pileus, that it was at once referred to that species when it was first observed. When it was closely examined, an interesting discovery was made. The spores were not only not like those of *R. varieta* but they were unlike the spores of any other species. They were thick-walled, smooth and nar-

Mycena glutinosa

rowly ellipsoidal so as to be almost cylindrical. *Russula ventricosipes* Peck certainly has smooth spores but the usual shape of spore in this genus is globose to round ellipsoidal. This spore difference was so marked that it seemed impossible that the plant could be a *Russula*, though an experienced collector from its appearance would at once refer it to that genus. During the past season this plant was found and studied again. The trama was found to have the typical vesiculose structure of *Russula* which places our plant in that genus in spite of its unusual spores. The diagnosis follows.

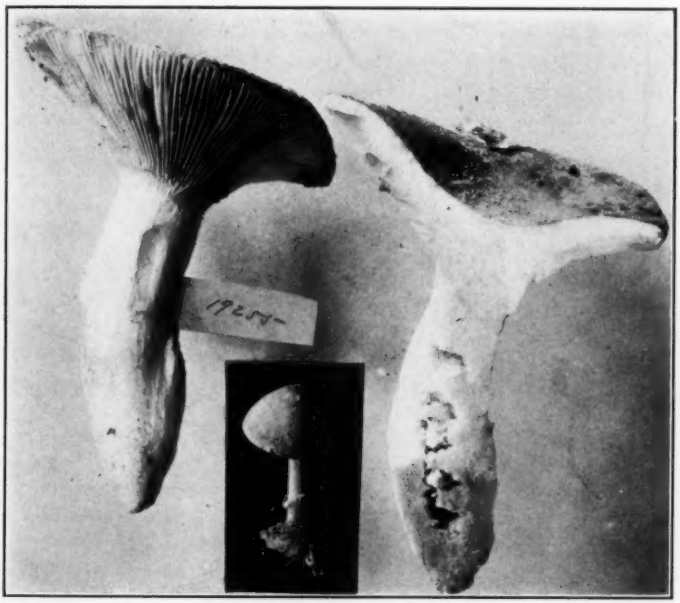
Russula heterospora sp. nov.

Pileo carnoso, rigido, convexo, demum depresso infundibuliformique, glabro, margine laevi et acuto, pallide carneo-roseo aut purpurino olivaceo commixto; stipite rigido, albo, glabro, solido, deorsum attenuato; lamellis attenuato-decurrentibus; angustis, confertis, furcatis; sapore et odore miti. Sporae laeves, albae, ellongato-ellipsoideae. 9–12 × 3.5–4.3 mc.

In nemoribus, Longwood Fla. *Russulae variatae* Banning simillima.

AMANITA PANTHERINA Fries

The occurrence of this species in the United States has seemed quite doubtful, although it has been reported several times. The



Russula heterospora
Inset Chamaeota pusilla Pat.

American species *Amanita cothurnata* Atkinson which is closely related to it is a common southern species, but it is consistently smaller and is pure white so that it is quite different in appearance.

What seem to be typical specimens of *A. pantherina*, however, have been found recently near Painesville, Ohio. They were ex-

actly like this species as Lloyd and I found and studied it in Sweden. The plants were robust, with the caps 10–12 cm. broad, and the stipes 10–14 cm. long and 2–2.5 thick, which is distinctly larger than is usual with *A. cothurnata* and instead of being pure white they were a deep sepia brown, with which the white fragments of the volva made a fine contrast. They had the stipe sheathed at the base and ellipsoidal spores 9–11 × 4–5 mc. which agrees well with the spores of both of these species, although the spores of *A. cothurnata* have been erroneously stated to be globose.

Whether *A. cothurnata* and *A. pantherina* are distinct specifically is a question on which mycologists will not agree, but at all events these Ohio plants are typical *A. pantherina* Fries and this species must be considered to belong in our flora, though it is doubtless rare.

PERRY, OHIO.

THREE NEW HETEROBASIDIOMYCETES

G. W. Martin

(with plate 31)

During the past few years I have examined a considerable number of tremellaceous fungi of which the characters do not seem to agree with those of any recognized species. Many of these have been collected by my students and myself; others have been sent in by correspondents. The confused state of the taxonomy of the group and the inadequacy of many of the descriptions make it desirable to use extreme caution in describing forms as new. The three species here presented seem, however, so clearly distinct as to justify description at this time.

Platygloea sphaerospora sp. nov. Plate 31, Figs. 1–2.

Late effusa, ceracea, margine indeterminato, separabilis, avellanea vel brunnea, hyphae tenues, 1.5–2 μ crass., dense intertextae; basidia cylindraceo-clavata, 25–30 $\times$ 6–8 μ, demum 60 $\times$ 5 μ, transverse 3-septata; sporae subglobosae, 7–8 $\times$ 5.5–6 μ.

Receptacle broadly effused, waxy, with indeterminate margin, separable, avellaneous to wood brown,[1] drying deep brownish red; hyphae slender, 1.5–2 μ in diameter, densely interwoven and more or less deliquescent; basidia at first swollen, clavate, 25–30 $\times$ 6–8 μ, later cylindrical-clavate, 60 $\times$ 5 μ, becoming transversely 3-septate, each cell producing a rather short epibasidium, 6–8 μ long; basidiospores subglobose, apiculate, 7–8 $\times$ 5.5–6.5 μ, germinating by repetition.

Type: G. W. M. *1222*, Dias Creek, Cape May County, N. J., Sept. 10, 1932, on rotten wood of *Quercus rubra* L. (*Q. falcata* Michx.). Another collection, G. W. M. 1191, same location and date and on same substratum.

Both fructifications were several centimeters in extent, but unfortunately only small portions were collected. No. *1222*, when moistened on October 20, 1932, shed spores freely.

[1]Indicates reference to Ridgway: Color Standards and Nomenclature.

Von Höhnel (Ann. Myc. **2**: 271. 1904) believed *Platygloea* Schröter 1887 to be a synonym of *Achroomyces* Bonorden 1851, and this view is adopted by Neuhoff (Bot. Archiv. **8**: 257. 1924). Reference to Bonorden's original description (Handb. Allg. Myc. 135) and to the slightly later description of *Achroomyces pubescens* by Riess (Bot. Zeit. **11**: 135. 1853) suggests that while this is not impossible, the fungi described by these early authors may well have been tuberculate fusariums. For the present, therefore, it seems preferable to use Schröter's generic name, particularly as the species here described is not erumpent and tuberculate, but broadly effused.

Sebacina sublilacina sp. nov. PLATE 31, FIGS. 3–10.

Effusa, ceracea, tenuis, hymenium pallidum, lilaceo-cinereum, sicca subinvisibilis, usque ad 7 cm. long., 1–2 cm. lat., in sectione 35–70 μ crass., cystidia fusiformia, 40–60 $\times$ 6–9 μ, probasidia subglobosa vel pyriformia, 7–10 $\times$ 6–7 μ, demum longitudinaliter septata; epibasidia 6–10 $\times$ 1.5 μ; sporae ovato-cylindracei, 6–7.5 $\times$ 3–4 μ.

Fructification waxy, broadly effused, separable when moist, very thin, indeterminate, forming irregular patches up to 7 cm. long and mostly 1–2 cm. broad, lilac gray to pale purplish gray [1] when moist, drying to an almost invisible film which appears as a faint lilaceous gray patch on the substratum; in section 35–70 μ thick, the densely packed basidia borne in tufts on longitudinal hyphae arising almost directly from the substratum, interspersed with tortuous, branched paraphysoids, which are apparently the branches which have borne basidia, and with scattered, thin-walled, hyaline, subfusiform, more or less tortuous cystidia, 40–60 $\times$ 6–9 μ, emergent for half their length and ending in a blunt, pointed tip; probasidia subglobose to obpyriform, 7–10 $\times$ 6–7 μ, becoming longitudinally septate into 4 or occasionally only 2 cells, mostly near the surface, hence the epibasidia rather short, 6–10 $\times$ 1.5 μ; spores ovate cylindrical, slightly curved, 6–7.5 $\times$ 3–4 μ, germinating by repetition.

Type: G. W. M. *1330*, Iowa City, Ia., Oct. 17, 1933, on dead oak branch. Not uncommon in Iowa, especially in late fall. Also Ohio, Missouri.

The prominent cystidia clearly mark this species as a member of the subgenus *Heterochaetella*, originally proposed by Bourdot as a subgenus of *Sebacina*, but later raised by its author to generic rank. Rogers (Univ. Iowa Studies Nat. Hist. **15**:[3] 9. 1933) points out

that the one character which distinguishes the group is not, in itself, of generic significance, and hence follows Rea and Burt in treating it as a subgenus. In this decision I concur. *S. sublilacina* differs from the other members of the subgenus in its very thin fructification, in the size and shape of the cystidia and in its spore dimensions.

Dacryomitra brunnea sp. nov. PLATE 31, FIGS. 11–14.

Tenaci-gelatinosa, gregaria vel congregata, 4–8 mm. alta; hymenophorum lobatum, contortum, 2–2.5 mm. latum, atrobrunneum; stipes crassus, sulcatus, basi pallidior; basidia clavata, 35–40 × 4–4.5 μ, epibasidia dua gerentia; sporae hyalinae, ovato-cylindraceae, uno latere depressae, demum 1-septatae, 9.5–12 × 4–5 μ; conidia ovata vel subglobosa, 3–4 μ.

Type: H. A. Kelly *773*, Parry Sound Region, Ontario, 1920, on coniferous wood. In herb. Univ. Mich.

Differing from all known species of *Dacryomitra* in the dark brown color as well as in the proportionately thick stalk and the flattened head. It is not, however, a *Dacryopsis*. Although flat, the head is definitely morchelloid and the stem is of the *Dacryomitra* type. When dry, the head is black and the stem dark reddish brown.

Since the tremellaceous fungi appear to have a not wholly deserved reputation as difficult to study, a word as to the methods used may not be out of place.

Whenever possible, a spore print should be secured. If the material is brought in from the field in expanded condition, provided it is neither immature nor over mature, all that is necessary is to wrap it in newspaper with the hymenium side down and in contact with a piece of black paper. For the larger fructifications a moist chamber is neither necessary nor desirable, but the smaller ones must be protected in some way against too rapid drying. If the specimen is dry when brought in, it must first be thoroughly soaked, preferably in distilled water, then dried on an absorbent surface, such as a towel, until the excess water is removed, and then wrapped in paper or placed in the moist chamber. Many species will give spore prints several weeks after being collected and dried in the laboratory. Such prints not only provide fully matured spores, but nearly always indicate the normal method of germination. Where this is by repetition, there may be several gen-

erations of secondary spores, those of each succeeding generation slightly smaller than those that gave rise to them, and due allowance for this fact must be made in interpreting spore measurements.

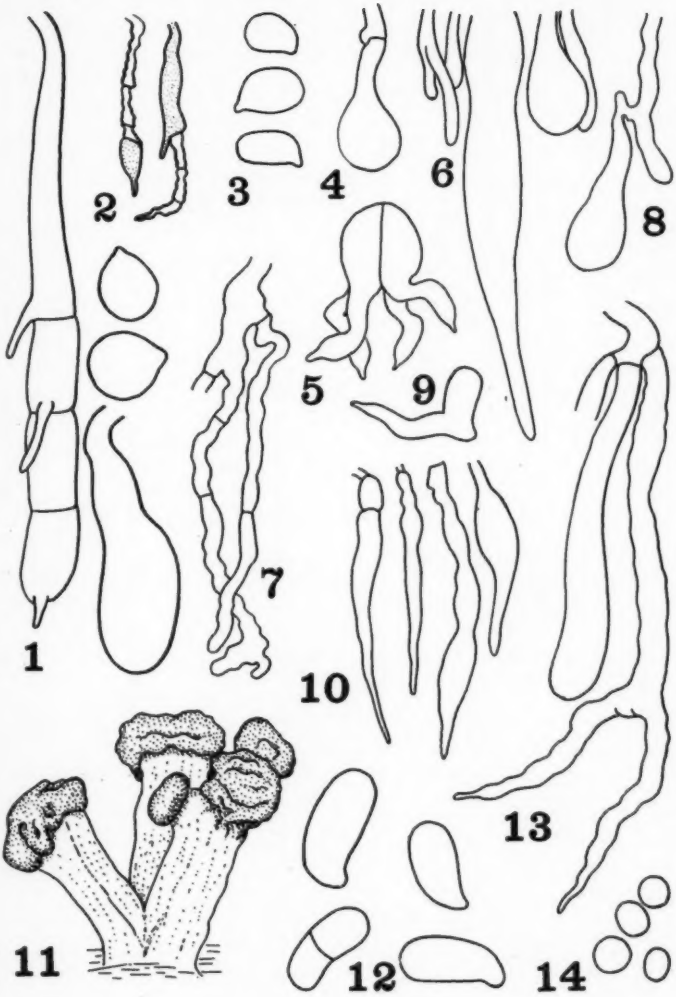
At least equally important is the fact that a fructification removed from a moist chamber or wrapping while shedding spores, and dried reasonably quickly in a moderately warm room will have many more basidia in various developmental stages than all but the most favorable collections as they come from the field. Excessive heat in drying should be avoided, as specimens which are dried too rapidly frequently fail to soak up properly when moistened later on.

The spore print is usually white, but may be pinkish or lilaceous, as in several of the commoner species of *Tulasnella,* or some shade of orange or yellow, as in many of the Dacrymycetaceae and a few species of *Tremella.* Where it is suspected that the spore color may not be white, part of the spore collection should be secured upon white paper, since the more delicate tints do not show up well against a black background.

As simple and elementary as these suggestions are, were they to be followed more generally in the collection and preservation of tremellaceous fungi, the material in our herbaria would be in far better shape for study than is now ordinarily the case.

For the demonstration of hymenial structures, staining is usually desirable. Our method has been to place either a thin section or a very small portion of the hymenium on a slide, drain off any water present, flood with a drop of alcohol, drain off the alcohol and quickly add a drop of 3 per cent aqueous potassium hydroxide and a small drop of 1 per cent aqueous Phloxine, mixing if necessary before putting on the cover slip. The hydroxide softens the material when it is tough or tenacious, permitting the separation of the hymenial elements by light pressure. Such a preparation usually fades in a day or so, but if the hydroxide is replaced by acidulated glycerine in proper dilution it makes a brilliant and permanent slide. For a denser stain, with indication of nuclei, Amann's medium with nigrosin is excellent.

For the determination of many important characters, sections are necessary. The waxy species present no difficulty. Con-



HETEROBASIDIOMYCETES

trary to general belief, however, the gelatinous species will provide very satisfactory sections if proper care is taken. A very sharp razor is needed and the material must not be too wet. If soaked and then dried until firm, good, thin sections may be secured in pith. Temporary distortion caused by pressure between the halves of the pith is ordinarily satisfactorily corrected by the hydroxide solution. Of course, for thin, entire sections of large fructifications, paraffin must be resorted to. In such cases dehydration by a butyl alcohol series seems to give better results than the use of ethyl alcohol.

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EXPLANATION OF PLATE 31

All microscopic drawings made with aid of camera lucida and reduced in reproduction to magnification indicated.

Fig. 1–2. *Platygloea sphaerospora.* Fig. 1, nearly mature basidium, probasidium and two spores, × 1500; Fig. 2, two basidia, the spores discharged from all but the terminal cell of that on the left, from all but the basal cell at the right, × 683.

Fig. 3–10. *Sebacina sublilacina.* Fig. 3, three spores to show variation in size and shape; Fig. 4, probasidium, with clamp connection at base; Fig. 5, mature basidium; Fig. 6, tip of cystidium protruding from hymenium, the latter showing a probasidium and paraphysoids; Fig. 7, tortuous, branched paraphysoids; Fig. 8, tortuous branch with swollen tip (probasidium?); Fig. 9, spore germinating by repetition. Fig. 3–9, × 1500. Fig. 10, four cystidia, to show variation, × 683.

Fig. 11–14. *Dacryomitra brunnea.* Fig. 11, habit, × 6; Fig. 12, four spores; Fig. 13, probasidium and collapsed basidium; Fig. 14, four conidia. Fig. 12–14, × 1500.

GODRONIA URCEOLUS AND OTHER CENANGIACEAE ON RIBES

EDITH K. CASH

(WITH PLATE 32 AND 1 TEXT FIGURE)

A collection of fungi made in Grand Mesa National Forest, Colorado, during the summer of 1930 by Mr. R. W. Davidson of the Division of Forest Pathology, was found to include three species of Cenangiaceae on *Ribes*, two of which were again found by Mr. Davidson in June 1933. One of these discomycetes has been identified as *Godronia urceolus* (Alb. & Schw.) Karst.; the others appearing to have been undescribed are here described as new species.

1. GODRONIA URCEOLUS (Alb. & Schw.) Karst. (PLATE 32, FIG. 1.)

Apothecia single or caespitose, substipitate, urceolate, membranaceous, .5–1 mm. diam. and height, dark greenish olive to olivaceous black,[1] exterior concentrically strigose from base to margin, wrinkled and paler at the margin; opening at first small, round, even, becoming lacerate, hymenium dark mouse grey; asci cylindrical, short pedicellate, slightly narrowed at the apex, 100–130 × 6–8 μ, usually about 110 × 7 μ; spores acicular, multiseptate, hyaline, acute at both ends, 66–75 × 1.5 μ; paraphyses filiform, branched near the tip; exciple composed of dark greenish olive, thick-walled, subcircular to elongate cells, with fascicles of darker hyphae in more or less regular streaks.

On twigs of *Ribes* (*?montigenum*), Grand Mesa National Forest, Colo., June 19, 1930, R. W. Davidson *363-a*; on *Ribes* sp., June 11, 1933, R. W. D. *772-a*.

The fungus agrees with the description of *G. urceolus* given by Rehm (**7**, p. 238) and with that of Albertini and Schweinitz (**1**, p. 332). In the illustration of the latter (PLATE 3, FIG. 4), the

[1] Color terminology follows that in Ridgway, Color Standards and Color Nomenclature, Washington, 1912.

apothecia appear sulcate, but it is clear from the description that the apparent furrows are in reality striae of dark hyphae. Nannfeldt (**5**, p. 283) suggests that *G. urceolus* is restricted to *Alnus*, and does not occur on other hosts. Rehm (l.c.) lists *Betula alba*, *Symphoricarpus racemosus*, and *Ribes rubrum* in addition to *Alnus*, commenting on the more caespitose habit on *Ribes*. A specimen of *G. urceolus* f. *Betulae* on birch (Rehm, Ascomycetes *1977*), examined by the writer through the kindness of Dr. F. J. Seaver, does not appear to differ specifically from the fungus on *Ribes*. A specimen on *Ribes prostratum* from Ontario, ex herb. R. F. Cain *1517*, determined by Mr. Cain as *G. urceolus* is also apparently the same species as the Colorado material, although the average spore length is only 55 μ.

An interesting problem was presented by a pycnidial fungus associated with the apothecia of the *Godronia* in the 1933 collection (no. *772-a*). This was determined as *Mastomyces uberiformis* (Fries) Karst. (*M. Friesii* Mont.), agreeing in the olive-brown to black pycnidia, emerging from a basal stroma and exuding masses of spindle-shaped, 3-septate spores, borne on simple or branched conidiophores, such as described by Petrak and Sydow (**6**, p. 368). The pycnidia in the Colorado fungus are depressed-globose rather than conical, and less prominent than in some well-developed specimens of *M. uberiformis*, but there seems to be considerable variation in shape at different stages of maturity.

M. uberiformis (Fries) Karst. has been stated by various authors, apparently on the basis of Fuckel's assertion, to be a stage in the life history of *Scleroderris ribesia* (Pers.) Karst. In order to test this assumption, herbarium specimens of the two fungi, chiefly exsiccati, were examined. In no case was the Mastomyces found in association with *S. ribesia*. *Fuckelia Ribis* Bon., recognized by Fuckel and others as a stage of this discomycete, was the only conidial form present with it in the following: Allescher and Schnabl Fungi Bavarici *170;* Fries Scler. Suec. *131;* Holl. Schm. and Kunze Deutschl. Schw. *73;* Jaczewski, Komarov and Tranzsch. Fungi Ross. Exs. *43;* Krypt. Exs. Mus. Palat. Vindob. *2029;* Migula Crypt. Germ. Aust. and Helv. Exs. *216;* Nannfeldt Fl. Suecica *1011;* Petrak Fungi Alb. & Bosn.

Exs. *161;* Sydow Myc. Germ. *495,* and Vestergren Mic. Rar. Sel *932.*

On the other hand, whenever an apothecial stage was found associated with *Mastomyces* on the *Ribes* specimens examined, it proved to be not *Scleroderris ribesia,* but *Godronia urceolus.* Several specimens of *Mastomyces* showed either conidia only, or conidia with immature apothecia, having neither asci nor spores, as was the case in Vestergren Mic. Rar. Sel. *1769* on *Ribes rubrum* from Sweden, also in a specimen on *Ribes* sp. from Ontario, coll. H. S. Jackson, Univ. Toronto *3048.* In three instances, however, the *Mastomyces* was found in association with mature apothecia of *Godronia urceolus,* the characters of both apothecial and pycnidial forms agreeing with those in the Colorado specimen on *Ribes:*

Brenckle, Fungi Dakotenses *217* (conidia) and *217-a* (apothecia), as *Scleroderris ribesia* (Pers.) Karst. on *Ribes floridum,* Nyland Grove, N. Dak., May 4, 1913.

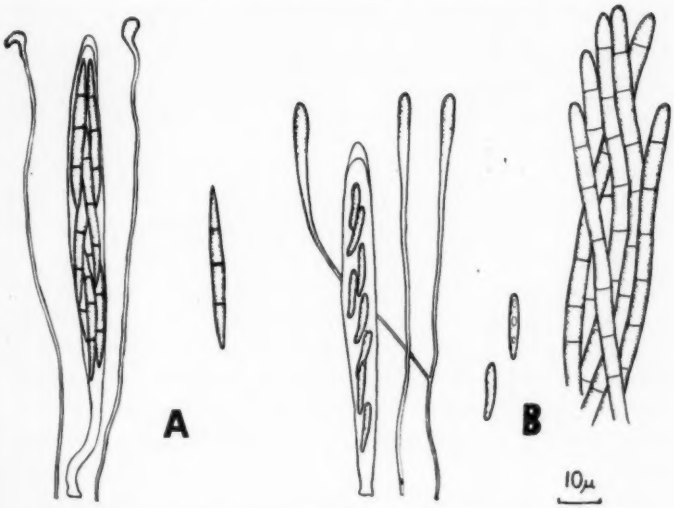
Phyt. Sect. Bot. Gard. U. S. S. R., *Mastomyces Friesii* Mont. socia *Godronia urceolus* Karst., on *Ribes nigrum,* Leningrad, coll. Vassiljevsky 5–16–1925.

Herb. Barbey-Boissier *2319, Mastomyces Friesii* Mont., on *Ribes nigrum,* Darmstadt, ex herb. Fuckel.

The apothecia in Fungi Dakotenses *217-a* have asci measuring 100 × 6–7 μ and acicular spores 60–75 × 1.5–2 μ, and are clearly not *Scleroderris* as labeled. The third specimen is particularly significant, since it is on Fuckel's statement (**3**, p. 267) that is based the connection of *Mastomyces uberiformis* with *Scleroderris ribesia.* In addition to the Barbey-Boissier number *2319,* the label of this specimen bears the notation " F. Rhen. *1583,*" and is apparently a duplicate of the Fuckel specimen of that number, which is cited (l.c.) as the " macrostylosporiferus " stage of *Cenangium Ribis,* or *Scleroderris ribesia.* As shown in the accompanying illustration (PLATE 32, FIG. 2) *Mastomyces* and *Godronia* are present on the same stroma in this material.

Conflicting statements are found in literature as to the conidial stage of *Godronia urceolus.* Von Höhnel's *Chondropodium urceolus* on *Cornus,* with spindle-shaped, 1-septate spores, 52–68

$\times$ 3–4 μ (**4**, no. 958, p. 46) is obviously a different fungus. Brefeld, on the other hand, found associated with *Godronia* on *Ribes* conical, black pycnidia, containing indistinctly 3-septate spores, 26–30 $\times$ 3–4 μ, borne on branched conidiophores. Mycelium developing from these in culture was identical with that from ascospores of *G. urceolus,* with which fungus he concludes that it is connected (**2**, p. 290–291). Brefeld does not name his pycnidial fungus, but it is unquestionably *Mastomyces uberiformis.*



A, Godronia Davidsoni: ascus, paraphyses and spore: B, Scleroderris tumoricola: ascus, paraphyses, spores, and marginal hairs

Cultural studies will be necessary to establish definitely the connection between these pycnidial and ascosporic fungi on *Ribes,* but from the present evidence it seems probable that *Mastomyces uberiformis* will prove to be a stage in the life history of *Godronia urceolus* and not, as has been supposed, of *Scleroderris ribesia.*

2. **Godronia Davidsoni** sp. nov. (PLATE 1, FIG. 3; TEXT-FIG. 1, A.)

Apothecia sessile or substipitate, erumpent, single, depressed-globose to urceolate, .5–.7 mm. in diameter and height, membranaceous, buffy-olive to dark greenish olive, slightly strigose,

wrinkled when dry, with circular opening and fimbriate margin, hymenium smoke-gray; asci cylindrical, gradually narrowed toward the base and at the apex, 8-spored, 90–120 × 5–7 μ, usually about 110 × 6 μ; spores parallel or slightly twisted, acicular-fusoid, 3-septate, hyaline, 33–45 × 2.5–3 μ; paraphyses filiform, simple, hyaline, gradually enlarged to 2–2.5 μ and frequently recurved at the tip; exciple dark-pseudoparenchymatic at the base, with occasional dark olive brown striae, becoming paler toward the margin.

Apotheciis sessilibus vel substipitatis, depresso-globosis, membranaceis, olivaceo-brunneis, .5–.7 mm. in diam. et altitudine, hymenio ochraceo-griseo; ascis cylindraceis, base et apice angustatis, 90–120 × 5–7 μ; sporis aciculari-bus-fusoideis, 3-septatis, hyalinis, 33–45 × 2.5–3 μ; paraphysibus filiformi-bus, continuis, hyalinis, ad apicem gradatim incrassatis et curvatis, 2–2.5 μ diam.

On stems of *Ribes Wolfii*, near Mesa Lakes, Grand Mesa National Forest, Colorado, June 27, 1930, R. W. Davidson *460; Ribes bracteosum* X *R. nigrum*, Juneau, Alaska, July 12, 1923, J. P. Anderson *758*.

Superficially this species bears a close resemblance to *Godronia urceolus*, from which it may be distinguished by the flattened, smoother apothecia and the shorter, broader spores; the spores of *Scleroderris ribesia*, on the other hand, are broader and clavate. Judging from the description, *G. Andromedae* P. Henn. is a very similar fungus, but no material of this is available for comparison.

3. **Scleroderris tumoricola** sp. nov. (PLATE 32, FIG. 4; TEXT-FIG. 1, B.)

Apothecia sessile, usually caespitose, rarely single, erumpent on canker-like swellings, cupulate to nearly patellate when expanded, triangular or irregularly contorted when dry, coriaceous, wrinkled, furfuraceous, blackish brown to black with paler fimbriate margin, .5–2 mm. diam.; hymenium avellaneous or light drab, drying nearly black; asci cylindrical, narrowed at the apex, 8-spored, 90–100 × 5–8 μ; spores biseriate or more frequently irregularly uniseriate, unicellular, clavate, guttulate, acute at the lower end, 10–15 × 1.5–2 μ; paraphyses filiform, hyaline, simple or branched about half-way from the base, gradually enlarged to 2 μ at the apex; hypothecium hyaline to pale yellowish, 100 μ thick; exciple of dark-brown, parenchymatic cells, 5–7 μ in diam., roughened

with fascicles of septate, smooth, brown hyphae, paler toward the margin, 130 × 3–5 μ.

Apotheciis sessilibus, cupulatis vel applanatis, coriaceis, nigrobrunneis, furfuraceis, 1.5–2 mm. diam.; hymenio avellaneo; ascis cylindraceis, apice angustatis, 90–100 × 5–8 μ; sporis bi- vel uniseriatis, simplicibus, clavatis, 10–15 × 1.5–2 μ; paraphysibus filiformibus, hyalinis, apice 2 μ.

On swollen, canker-like areas of twigs of *Ribes montigenum* found underneath the snow, Mesa Lakes, 9700 ft. elevation, Grand Mesa National Forest, Colo., June 13, 1930, R. W. Davidson *231* (type); on *Ribes* sp., June 11, 1933, R. W. D. *772-b*.

Spore septation in *Scleroderris* is extremely variable, dependent on the degree of maturity of the material. Long, clavate spores, like those in the fungus described, are frequently simple at first, with homogeneous contents, later becoming many-guttulate and remaining non-septate for a considerable time, but eventually showing one or more distinct septa. It seems preferable therefore, to place the fungus in *Scleroderris* rather than *Cenangium*, even though no septate spores have been observed. The presence of the fasciculate, septate hyphae suggests *Crumenula*, to which pilose species of the Cenangiaceae are usually referred; forms with more or less well-developed hairs are, however, included under other genera of the family and the limits of the genus are not clearly defined. Nannfeldt (**5**, p. 283) in the most recent treatment of the group, includes *Crumenula* as a synonym of *Scleroderris*.

Type specimens of the two new species have been deposited in the Mycological Collections of the Bureau of Plant Industry, the Herbarium of the New York Botanical Garden, and the Farlow Herbarium of Harvard University.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

EXPLANATION OF PLATE 32

Fig. 1. *Godronia urceolus* on *Ribes* sp., Davidson *772-a*, × 3.
Fig. 2. *Mastomyces Friesii* and *Godronia urceolus* on *Ribes nigrum*, Herb. Barbey-Boissier *2319*, × 10.
Fig. 3. *Godronia Davidsoni* on *Ribes Wolfii*, Davidson *460*, × 3.
Fig. 4. *Scleroderris tumoricola* on *Ribes montigenum*, Davidson *231*, × 3.
Photographs made by M. L. F. Foubert.

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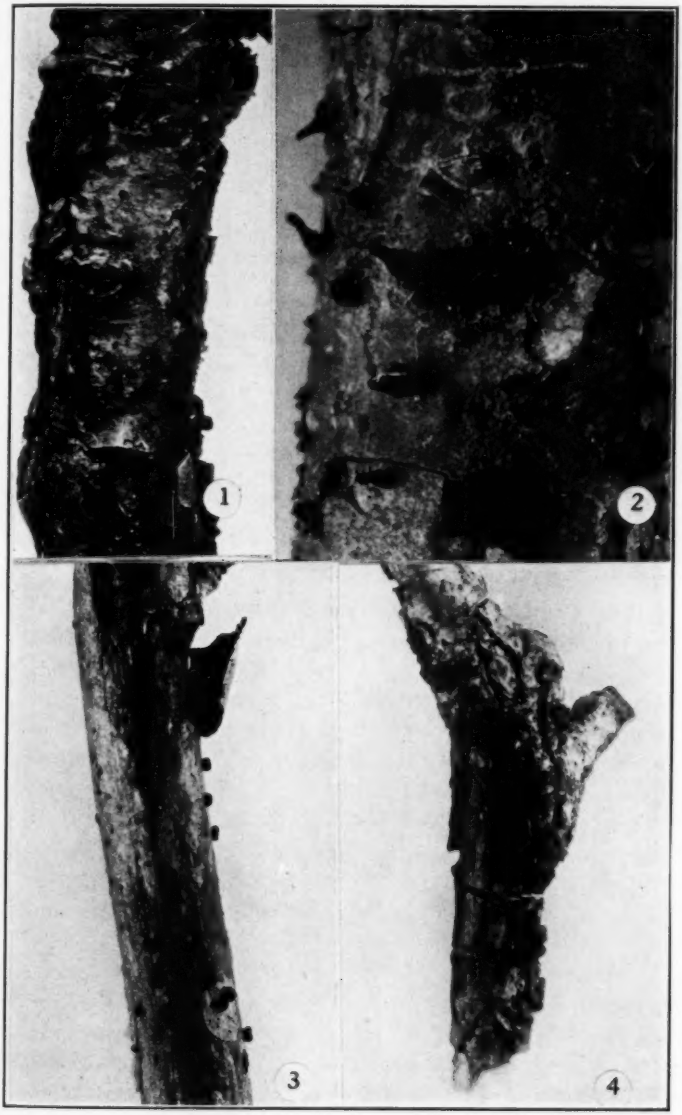

CENANGIACEAE ON RIBES

NOTES AND BRIEF ARTICLES

Wehmeyer's Diaporthe and its Segregates

In this volume, issued as the University of Michigan Studies, scientific series, volume 9, Wehmeyer treats the following genera, *Diaporthopsis, Apioporthe, Diaporthe, Diaporthella* and *Cryptodiaporthe.* The following new species are described: *Diaporthe dakotensis, D. Opuli, D. Bakeri, D. Fagi, D. Hickoriae, Cryptodiaporthe Macounii, Apioporthe Corni,* and *Diaporthopsis appendiculata.* The known species are described and many new combinations proposed. Of the three hundred and forty nine pages, one hundred are devoted to doubtful and unseen species. The volume contains much information on this important genus and it's segregates.

Buller's Researches on Fungi

Volume V of this well known work appeared January 3, 1934. The volume consists of two parts, the first devoted to hyphal fusions and protoplasmic streaming in the higher fungi, and the second to production and liberation of spores in certain non hymenomycetous basidiomycetes. The second part consists of three chapters. The first is a treatment of *Sporobolomyces,* a basidiomycetous yeast-plant and its spore discharge. The second chapter treats of the violent discharge of the basidiospores (secondary conidia) of *Tilletia Tritici,* and the third chapter discusses the *Sphaerobolus* gun and its range. The entire volume consists of 416 pages and is illustrated with 173 figures. The book is published by Longmans, Green and Co.

Another Rare Phalloid

Under the title "A Rare Phalloid From The New York Botanical Garden" (Mycologia **23**: 83. 1931) the writer reported the occurrence of *Colus Schellenbergiae* Sumstine, in a very restricted area in the Garden where it had reappeared every season for a number of years. It was at that time suggested that it

Fig. 1. Anthurus borealis

might be a synonym of *Colus javanicus* Penzig, reported from Java and this has since been found to be true. The only other known record for this species from continental North America is the collection from Pittsburgh from which Sumstine drew his description.

While it is a well known fact that many of the fungi are cosmopolitan in their distribution in the same latitude throughout the world, we ordinarily think of the tropical fungi as being more restricted. The appearance therefore of a supposedly tropical fungus in a northern latitude is of more than usual interest.

During the present season another rare phalloid was collected by Dr. A. B. Stout in one of his seed beds in The New York Botanical Garden. This was determined by the writer as *Anthurus borealis* and while more common than the preceding is still regarded as a rare fungus. A colored illustration of this species appeared in a early volume of Mycologia (**4**: PL. 68, FIG. 8). This was prepared by Dr. W. A. Murrill from material collected on Blackwell's Island in New York City. The species was described by Dr. E. A. Burt in 1894 from material collected in New York State. The name "*borealis*" apparently suggests that it is a northern species of what is usually looked upon as a tropical genus. It has since been several times collected in various parts of the East.

In 1920 (Mycologia **12**: 37) Dr. Murrill reported the species as having been collected by Mr. Kenneth Boynton in gladiolus beds in The New York Botanical Garden. The recent collection by Dr. Stout represents a second record of this species from The New York Botanical Garden. Since it apparently occurs at such rare intervals, or at least is rarely observed, it is worthy of record and illustration. The accompanying photograph (FIGURE 1) was made from material collected by Dr. Stout. The younger specimens were developed in moist chamber.—F. J. SEAVER.

A POISONOUS BOLETUS FROM OREGON

During the examination and identification of a species of *Boletus* the writer tasted and apparently swallowed a very small piece of the inner flesh. Three hours later typical symptoms of mushroom poisoning became apparent. Vomiting occurred frequently. Bil-

iousness was accompanied by severe stomach cramps and diarrhoea. A slight thirst was experienced but water could not be retained on the stomach. A physician was called and two hours after the first symptoms began, an injection of 1/50 grain of atropin was administered. At about the same time hot-towel packs applied to the affected region gave slight relief. Bismuth and tincture of opium given internally were soon expelled. The atropin was very rapid and effective in its action, taking less than five minutes to relieve the cramped condition, after which rest and quiet were possible. One vomiting spell occurred twelve hours later but was not severe. Coffee gave relief from thirst and was retained after this last attack. No bad effects other than weakness and sore chest muscles were apparent the following day. If a larger portion had been tasted, however, additional and more severe symptoms no doubt would have resulted.

These symptoms of mushroom poisoning were suggestive of those produced by *Amanita muscaria*, the fly agaric. A specimen sent to Dr. H. B. Myers of the University of Oregon Medical School for analysis, however, gave no evidence of a muscarin type of active principle by either chemical or biological methods.

Dr. S. M. Zeller kindly identified the *Boletus* under consideration which appears to be the western form of *B. satanus* of the *Luridi* group, known as *Boletus Eastwoodiae* (Murrill) Sacc. and Trotter. The original plants were very small due to a lack of soil moisture but later collections agree well with Dr. Zeller's notes on this species. The plants were found several times during September and October, 1933, in the Oak Grove district of the Hood River Valley, Oregon, being associated with trees of *Quercus garryana*.

This is believed to be the first definite report of poisoning by this fungus, although Murrill has previously classified it as suspected.

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Mycological Society of America

THE SUMMER FORAY

The second annual summer foray of the Mycological Society of America will be held at Seventh Lake, near Inlet, N. Y., in the southwestern Adirondack Mountains, August 21 to 24 inclusive. Headquarters will be at the camp of Professor F. C. Stewart. His boat-house will serve as our laboratory, and will be provided with a small working library, several microscopes, and a moderate supply of blotter driers and plant presses. Other items such as vasculums and baskets should be brought by those attending the foray.

Living accommodations can be obtained at hotels in the vicinity. The nearest railroad station is Thendara, 15 miles distant. Seventh Lake is one of the famed Fulton Chain, and has long been regarded as one of the most attractive of the many lakes in that region. It is surrounded by dense forest, and yet is available over splendid state roads. It lies considerably to the south of the highest of the Adirondacks, but these can be reached by automobile in a few hours. All who plan to attend the foray are asked to advise either the secretary-treasurer or Professor Stewart as far in advance as possible and make known what kind of accommodations they desire in order that adequate arrangements may be made. Both are thoroughly familiar with the region and will be glad to answer inquiries. Tenting is a possibility. Those thinking of using tents should obtain Recreation Circulars 2, 3 and 7 of the Conservation Department, Albany, N. Y. No charge is made for them. The Conservation Department furnishes also an excellent map of the Adirondack Mountains at a price of 15 cents.

Professor Stewart made the facilities of his camp available in the summer of 1931 at the occasion of a mycological foray held by American students of the Agaricaceae for Doctor Jakob E. Lange. In earlier years Professor Atkinson, Doctor Kauffman, and other prominent students collected there. A list of the higher fungi of the neighborhood has been kept which embraces about 670 species. The collecting when at its best is excellent, and in any August is good. Pleasant days and cool nights are guaranteed. There are no poisonous snakes, and at that season of the year few insects.

An easy climb to the summit of Black Bear Mountain nearby affords a pleasing panorama of the entire region. Members of the Society and other mycologists are urged to make careful note of the dates of the foray, and to arrange their summer plans to include it. This annual get-together in the field affords an opportunity for personal contact and exchange of ideas, and it may well develop into one of the most important of the Society activities.

B. O. DODGE, F. C. STEWART, H. M. FITZPATRICK,
Committee on Arrangements

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